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Journal of Entomology and Zoology

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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor

Claremont, California, U. S. A.

New Californian Spiders

RALPH V. CHAMBERLIN

The new spiders described below were found recently while identifying a collection from Claremont received from Prof. Hilton and one made by the writer in the same region in 1909 and 1913. A few forms from other localities noted in making comparisons are also included.

AVICULARIIDAE

Hexura fulva sp. nov.

Carapace and sternum with labium and endites yellow of light reddish cast, unmarked excepting for the solid black interocular area. Legs pale yellowish brown without the reddish tinge. Chelicerae typically a little darker than the carapace. Abdomen grey above and either wholly unmarked or sometimes showing a short median longitudinal pale line at base; venter paler excepting toward the spinnerets, where darkened; spinnerets pale brown like the legs. Chelicerae long, clothed above on mesal portion with long setae which are more abundant on the anterior face below. Anterior lateral eyes much the largest, less than their long diameter apart, scarcely three times the diameter of the medians. Anterior median eyes about their radius apart, between two-thirds and three-fourths the diameter of the posterior medians, which are smaller than the posterior laterals. Tibiæ I and II armed beneath with 3-1-1 spines, the two unseries spines being at distal end. Metatarsi I and II armed beneath with 3-3 spines. Spinnerets with articles proportioned much as in *picea*, the terminal article being pointed and subannulate, but the length rather shorter than the width of the abdomen and much shorter than its length.

Length, 9 mm. Length of cephalothorax, 4 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.2 mm.

Type—M. C. Z. 380. Claremont.

A much lighter colored species than *picea*, the genotype, and differing in the much shorter spinnerets, in having 3-3 spines instead of 2-2 below on metatarsus I, in having the anterior lateral eyes scarcely three times instead of more than four times the diameter of an anterior median, in the proportionately broader endites, etc.

Nemesoides gen. nov.

Pars cephalica of moderate size. Fovea thoracica moderate, recurved. Anterior row of eyes procurved, median eyes much smaller than the laterals. Lateral eyes on each side less than their radius apart, the anterior scarcely larger than the posterior. Rastellum of chelicerae well developed, the teeth long and stout. The labium broader than long, unspined. Endites armed at base with a patch of slender spines. Sternum with a pair of large impressions united at middle and in transverse line with them, near, but separated from, each lateral margin a much smaller impression. Tarsal claws with teeth numerous, in two sinuous series. Tarsi and, in part, metatarsi of first two pairs of legs scopulate. Tarsi of last two pairs of legs spined (male, genotype.) Metatarsus IV shorter than tibia IV. Superior spinnerets large, four-jointed, the distal joint short, rounded, shorter than the third and much shorter than the second. Tibia I of male with spur.

Genotype—*N. hespera* sp. nov.

This genus falls in Simon's group *Nemesiæ* in its more restricted sense.

Nemesoides hespera sp. nov.

Male.—Carapace, sternum, labium and endites and legs yellowish. Chelicerae darkened distad by the black teeth of the rastellum. Abdomen yellowish beneath; light brown above, with three longitudinal rows of short, black, transverse marks. Chelicerae long and rather slender, extending almost directly forward, not at all geniculate, the lower teeth of rastellum stout. Anterior row of eyes procurved in such manner that the line tangent to the lower edges of the median eyes passes through or near the centers of the laterals; lateral eyes with diameter twice that of the medians; median eyes their diameter apart. Anterior and posterior lateral eyes equal or very nearly so, separated by less than half their radius. Posterior median eyes nearly of same size as the anterior medians from which separated by their radius, closer to the posterior laterals. Tibia I in male with spur or process; strongly spined; a series of long, stout spines along each side, fewer smaller ones beneath, typically a short, oblique row of four close-set and especially stout spines at the ectoventral corner of the distal end. Metatarsus I with a strong angle, or process, at middle of the ventral edge. Palpal organ as shown in pl. 1, fig. 1.

Length, 10 mm. Length of cephalothorax, 5 mm. Length of tib. + pat., 1.5 mm.; of tib. + pat. IV, 5.5 mm.

Type M. C. Z. 379. Claremont. Wm. A. Hilton coll.

DICTYNIDÆ

Amaurobius nigrellus sp. nov.

Female.—Carapace dusky chestnut to nearly black. Sternum solid black. Labium and endites black or blackish excepting across tips. Legs dusky brown, the femora darker, blackish. Abdomen above and laterally blackish brown, the background black lightened by numerous minute yellowish dots; venter mesally immaculate black. Anterior median eyes their diameter apart, once and a half as far from the laterals. Posterior row of eyes but little longer than the anterior; median eyes nearly twice their diameter apart, and almost two and a half times their diameter from the laterals. Area of median eyes wider behind than in front and longer than wide. Tibia I unarmed. Anterior metatarsi well spined beneath. Tibia IV with four spines beneath, these in a longitudinal line with an extra one at distal end. Tibia III and IV with a small spine at the base above, in this differing from the other known North American species. Lower margin of furrow of chelicerae armed with two teeth. Epigynum a plate subcordate in outline with a median longitudinal band extended laterad on each side behind.

Length 6 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, the same.

Type—M. C. Z., 374. Cal., Claremont. Prot. Wm. A. Hilton.

Parauximus gen. nov.

Resembles *Auximus* in eye characters, but eyes of both rows nearly equidistant. It differs in having the lower margin of the furrow of the chelicerae armed with eight teeth, instead of four or five, of which the most distal instead of the most proximal is largest; upper furrow with three teeth of which the median is largest. A notable feature of the genus is that the patella of the male palpus, at least in the genotype, bears a stout apophysis.

Genotype.—*P. tardatus* sp. nov.

Parauximus tardatus sp. nov.

Male—Carapace dusky over light brown. Legs with somewhat obscure dusky annuli over yellow. Labium and endites chestnut, pale across tips. Chelicerae dusky chestnut. Abdomen dark over sides, dorsally a pointed mark outlined in black from base to middle, followed by a series of mesally connected chevron marks. Venter immaculate light grey with an angular extension from the dark of each side just in front of the spinnerets, the two processes not meeting in the middle line. Lower margin of the furrow of the chelicerae bearing four large teeth and proximad of these four smaller ones. Anterior median eyes very small, rather less than half the diameter of the laterals, near their diameter apart and about the same distance from the laterals. Posterior row of eyes straight; median eyes smaller than the laterals. About their diameter apart and the same distance or a little less from the laterals. Anterior laterals larger than posterior laterals and separated from them by about a radius of the latter. Tibiae and metatarsi I and II armed beneath with three pairs of spines.

Palpus as shown in plate 1, fig. 2. Patella with a stout apophysis bearing distally numerous spines.

Type—M. C. Z. 377. Claremont.

Readily distinguishable by the characters of the eyes and the structure of the male palpus.

Auximus pallescens sp. nov.

Female—A species in appearance much resembling the preceding, though typically paler with the carapace and legs much more yellow. Sternum yellow. Labium chestnut, pale across tip, the endites lighter; also distally pale. Abdomen colored somewhat similarly to that of the preceding species, but the dorsal markings in the type indistinct. The species is easily distinguished from the preceding by its much larger anterior median eyes, which equal or nearly equal the laterals and obviously exceed the posterior medians and which are separated from each other by rather less than their radius and from the laterals by not more than once and a half their diameter. Posterior median eyes separated by near once and two-thirds their diameter and from the laterals by twice and a half their diameter, the laterals much larger. Lateral eyes on each side separated by their radius or less. Lower margin of furrow of chelicera armed with four teeth. Tibiae I and II and metatarsi I and II each armed beneath with three pairs of spines. Epigynum, apparently not quite fully chitinized, shown in plate 1, fig. 3.

Length 12.5 mm. Length of cephalothorax, 6 mm. Length of tib.+pat. I, 5.7 mm.; of tib.+pat. IV, the same.

Type—M. C. Z. 376. Wm. A. Hilton coll.

Auximus latescens sp. nov.

Female—Carapace pale chestnut tending to testaceous in posterior and lateral regions. Legs testaceous to brown, the anterior ones often of slight chestnut cast. Sternum pale chestnut and the endites and labium darker chestnut. Chelicera dark chestnut or mahogany. The abdomen above is dark brown to blackish, with a posteriorly pointed pale mark reaching from base to middle followed by a series of pale chevron marks and on each side of it with usually three pale spots, which may be more or less connected with it or sometimes a short light line each side; venter grey-

ish brown to yellowish with two rather wide longitudinal dark stripes which are but narrowly separated on each side from the dark of the sides. Anterior lateral eyes with diameter once and two-thirds that of the medians; median eyes about five-sixths their diameter apart, twice and a half their diameter from the laterals. Lower margin of furrow of chelicera with four teeth, of which the most proximal is largest. Tibiæ I and II armed with five spines, one at base, two sub-median and two apical. Epigynum as shown in plate 1, fig. 4.

Male.—Carapace and legs somewhat paler than in the female. Eyes less widely separated. Palpal organs as represented in plate 1, fig. 5.

Type.—M. C. Z. 372. Cal.: Claremont. Type taken by the author in 1909. Paratypes taken in 1913. Also in 1918 coll. of Prof. Hilton.

The genus to which this and the preceding species belong, known from South America and the Atlantic Islands, has not previously been recorded from North America.

Diutyna mians sp. nov.

Female.—Pars cephalica yellowish, other parts of carapace brown to fuscous. Sternum yellowish, sometimes a little dusky, with the labium similar, but endites ordinarily paler. Legs not annulate in the types though the femora may be slightly darkened and the tibia and metatarsus show vague darkening at distal end. Abdomen above yellowish, with a dark spot in front of middle from which some fine dark lines radiate and anastomose to form a network, the median longitudinal line the best developed of these; typically three pairs of widely separated dark spots on posterior portion, but these often broken or indistinct. Venter darker, sometimes a median yellow spot in front of the cribellum with one in each edge of dark area. Anterior row of eyes straight; median eyes their diameter or a little more from the laterals, farther from each other. Posterior eyes nearly equidistant. Area of median eyes wider behind than in front. Epigynum, plate 3, fig. 8.

Type.—M. C. Z. 385.

Cal. Los Angeles Co. (R. V. Chamberlin); also northern part of state (Peckham coll.).

Has resemblance to *P. calcarata*, occurring in the same localities, but easily distinguished by the structure of the epigynum and the more widely separated eyes.

SCYTODIDÆ

Plectrocygus suprenans sp. nov.

Female.—Differs at sight from *P. castanea* Simon, which occurs in the same region, in its much longer legs, lighter, more dilute chestnut, carapace, and the proportionately shorter and higher abdomen. The legs are brown, of less chestnut cast, with the first ones not contrasting by deeper, fuscous color. Sternum pale chestnut like the carapace. Abdomen emereous of slight greenish cast, with pale median mark on dorsum at base. The anterior row of eyes is longer than in *castanea* with the lateral eyes comparatively smaller, their diameter not exceeding once and a half that of the medians; median eyes about their radius apart, much farther removed from the laterals than in *castanea*, the distance being from two and a half to three times their diameter. Posterior row of eyes distinctly a little recurved instead of straight, with the median eyes larger than the laterals instead of a little smaller,

separated by their longer diameter or more, a little nearer to the laterals. The trapezium of median eyes is much wider in proportion to the length than in *castanea*. Tibia I with five to seven long, widely separated spines on ventral side, of which none are paired or, rarely, eight present with two at distal end. Spines under metatarsus I shorter, very numerous.

Male—Tibia I of palpus without apophysis at distal end. Palpus represented in plate 2, fig. 1.

Length of female, 11 mm. Length of cephalothorax, 5 mm. Length of tibia + pat. I, 6.4 mm.; of tib. + pat. IV, 4.7 mm.

Type—M. C. Z. 368. Cal.: Los Angeles, Claremont. R. V. Chamberlin coll., 1909. Wm. A. Hilton coll., 1918.

DRASSIDÆ

Drassodes celes sp. nov.

Female—Carapace and sternum with endites and labium testaceous, and legs yellow. Chelicerae darker brown or pale chestnut. Abdomen ventrally clear yellow in front of the genital furrow excepting the dark epigynal area; behind the furrow dusky grey over a yellow background; dorsally dark olive grey due to dense clothing of hair. Upper margin of furrow of chelicera with three teeth of which the median is largest; lower margin with two small teeth. Anterior row of eyes rather strongly procurved; median eyes a little more than their diameter apart and a little more than their radius from the laterals, which are nearly their diameter from lower edge of clypeus. Posterior row of eyes scarcely procurved, much longer than the anterior row; lateral eyes smaller than the anterior laterals from which separated by once and a half the diameter of the latter; median eyes oblique, scarcely more than their long radius apart, twice their long diameter and nearly three times their lesser diameter from the smaller laterals. Tibiæ I and II armed beneath with but a single spine, which is attached a little distad of middle and toward the mesal side. Metatarsi I and II with a single spine beneath, this at base. All tarsi scopulate. Anterior metatarsi, and metatarsus III at distal end also, scopulate. Epigynum represented in pl. 2 f. 2.

Length, 10 mm. Length of cephalothorax, 4.5 mm. Length of tib. + pat. I, 4.5 mm.; of tib. + pat. IV, 5 mm.

Type—M. C. Z. 360. Cal.: Claremont. Wm. A. Hilton.

An obviously larger species than *D. robustus* which has a very different epigynum and bears no spine under tibia I. Only the male of *D. californicus* is known; but this may be distinguished from the present species by its different eye relations; e. g., in having the posterior laterals larger than the medians and the latter farther apart. It also has two pairs of spines under tibia, I which may not be a secondary character.

Scotothaeus voluntarius sp. nov.

Female—Carapace, sternum and legs pale chestnut, the posterior legs and the coxae beneath more brown and the anterior legs dusky or blackish beyond the femora. Endites like sternum, the labium and chelicera a darker chestnut. Abdomen blackish grey above and laterally, with a faintly indicated pale mark at base above; venter yellow in front of genital furrow and dusky greyish yellow behind it, with a pair of interrupted longitudinal dark lines. Epigynum blackish. Furrows of chelicerae unarmed. Anterior row of eyes procurved; median eyes between one-half and three-

fourths their diameter apart, only about one-eighth their diameter from the much smaller lateral eyes and less than their diameter from the lower edge of clypeus. Posterior row of eyes a little longer than the anterior, a little procurved; median eyes their diameter or scarcely more apart, closer to the laterals. All tarsi with well developed scopulae and the anterior metatarsi also scopulate. Tibiæ I and II each with a single spine at distal end beneath and metatarsi I and II each with one at base beneath. For form of epigynum see pl. 2, f. 3.

Length 8.5 mm. Length of cephalothorax 4 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3, 1 mm.

Type—M. C. Z. 361.

Herpyllus pius sp. nov.

Female—This large form in general appearance resembles *H. validus*, which is common in the same region; but, aside from readily noted differences in eyes and especially in the epigynum, it may easily be distinguished in having no spines beneath on tibia I, whereas *validus* has three spines as on tibia II, which is similarly armed in the present species. Carapace and legs pale chestnut. Sternum and endites similar but the labium and chelicerae darker. Abdomen grey, densely clothed with hair, as usual, the type not showing any definite markings. Hairs of plumose type, as usual. Posterior row of eyes considerably longer than the anterior, clearly procurved; median eyes circular, subequal to or scarcely smaller than the laterals, slightly more than their diameter apart and twice their diameter from the laterals. Anterior median eyes considerably larger than the laterals, their radius apart, closer to the laterals. Furrow of chelicerae armed above with three small teeth, below with one. For epigynum see pl. 2, f. 4.

Length, 11 mm. Length of cephalothorax, 5 mm. Length of tibia patella I, 4.5 mm.; of tib. + pat. IV, 5 mm.

Type—M. C. Z. 365.

Cal.: Claremont. R. V. Chamberlin coll., 1909.

Zelotes taiho sp. nov.

Female—Carapace and sternum reddish yellow, the legs yellow without the reddish cast. Endites like sternum, the labium and chelicerae darker. Abdomen grey without distinct markings. Posterior row of eyes distinctly longer than the anterior, a little procurved; median eyes elongate, elliptic, very oblique to each other, larger than the laterals, separated from each other by less than their radius, nearly their diameter from the laterals. Anterior median eyes smaller than the laterals, about their radius apart, not more than half as far from the laterals. Lateral eyes on each side separated by more than their radius but less than their diameter. Tibia I unarmed beneath, metatarsus I with a ventral spine at base. Tibia II beneath with a submedian spine, metatarsus II with a spine at base. Form of epigynum represented in pl. 2, f. 5.

Length, 6.5 mm. Length of cephalothorax, 2.9 mm. Length of tib. + pat. I, 1.4 mm.; of tib. + pat. IV, nearly the same or slightly less.

Type—M. C. Z. 367. Claremont.

Zelotes irritans sp. nov.

Male—Carapace, sternum, legs, and mouthparts dusky over a yellow background,

the anterior tibiae more blackish than the posterior. Abdomen greyish black. Posterior row of eyes but little longer than the anterior, slightly procurved; median eyes broadly slightly obovate, much larger than the laterals, separated from each other by less than their radius, twice as far from the laterals. Anterior median eyes very much smaller than the laterals, to which they are very close, separated from each other by their diameter. Tibia I armed beneath with a single submedian spine; tibia II armed beneath with three spines, two of these being submedian and at slightly different levels and one sub-basal. Palpus as shown in pl. 2, f. 6.

Length, 5.1 mm. Length of cephalothorax, 2.25 mm. Length of tib. + pat. I, 2.1 mm.; of tib. + pat. IV, 2.5 mm.

Type M. C. Z. 366. Claremont.

Zelotes gynethus sp. nov.

Female—A dark colored species having the general appearance of *Z. niger* but readily distinguishable in its smaller and very differently formed epigynum, etc., and from other species also by that character and those of the eyes. Carapace black of slight chestnut cast, shining. Legs dusky mahogany or the proximal joints, especially of the anterior pairs, solid black. Sternum dusky chestnut, the labium and endites similar. Abdomen greyish black above, paler beneath, without markings. Posterior row of eyes very slightly procurved, considerably longer than the anterior row; median eyes nearly their diameter from the laterals and a little nearer to each other. The anterior median eyes are characteristically very small, being greatly exceeded by the laterals from which separated by not more than half their radius, separated from each other by once and a half or more their diameter. No ventral spines on tibiae I and II or on corresponding metatarsi. For form of epigynum see pl. 3, f. 1.

Length, 8 mm. Length of cephalothorax, 3.1 mm. Length of tib. + pat. I, 2.9 mm.; of tib. + pat. IV, 3.4 mm.

Type—M. C. Z. 363. Cal.: Claremont.

Zelotes ethops sp. nov.

Male—Carapace and legs brownish yellow, the sternum clearer yellow. Labium darker than sternum, the endites like sternum. Chelicerae brown. Abdomen grey. The species seems readily distinguishable from those described previously from North America in the atypical character of the eyes and endites. The posterior row of eyes, which is straight, not at all longer than the anterior, the eyes all being close together, the medians but slightly separated and but little farther from the somewhat smaller laterals. The anterior row of eyes procurved with the laterals but little more than their radius removed from the edge of the clypeus; the median eyes, which are much smaller than the laterals, separated by but little more than their radius and much closer to the laterals. Lateral eyes on each side much nearer to each other than the medians, separated by less than their diameter. Chelicerae armed above with three small teeth, below with two. The endites are characterized by having the palpus inserted at or a little distad of the middle, obviously farther distad than usual. Tibia I and metatarsus I unarmed beneath; tibia II also unarmed beneath but metatarsus II with two spines in longitudinal line beneath. Anterior spinnerets large, much exceeding the posterior.

Length of not fully mature male type, 6 mm. Length of cephalothorax, 3.1 mm. Length of tib. + pat. IV, 3.4 mm.

Type M. C. Z. 362. Cal.: Claremont.

PHOLCID

Psilochorus californiae sp. nov.

Carapace, sternum, and legs yellow or the carapace and legs proximally of pale brown cast; the femora proximally and the patella and tibiae at ends often tinged with bright red. The head and the furrows commonly darker than other parts of carapace, with the eyes enclosed in black. The abdomen to the naked eye appears grey, commonly of a greenish tinge; under the lens it shows on the sides numerous light, somewhat silvery, spots and above a basal pale mark, with several pairs of dark spots enclosed by the light ones and often more or less subdivided. Posterior row of eyes straight; the median eyes nearly their diameter apart, their radius or a little more from the anterior lateral eyes, and three-fourths their diameter from the anterior medians. Anterior eyes in a strongly procurved row, with the medians much the smaller, as usual. In the male the apophysis on the chelicera is attached near the middle of the anterior face and projects directly downward or a little forward of downward; it is smaller than in *cornutus* and differs also in position and form from that in *fullulus*. Pl. 3, f. 2. The species is most readily recognized by the structure of the male palpus, which is represented in pl. 3, f. 3.

Length (male), 3.2 mm. Length of femur I, 4.8 mm.; of femur IV, 3.8 mm.; of tib. — pat. I, 5 mm.; of tib. — pat. IV, 4 mm.

Type—M. C. Z. 370.

Cal. Claremont. R. V. Chamberlin coll., 1909. Also Wm. A. Hilton coll., 1918.

THERIDIID

Lithyphantes mimoides sp. nov.

Female.—Carapace reddish brown or chestnut, darker on lower part of sides and with an obscure median longitudinal dorsal line on pars cephalica at least. Sternum chestnut, sometimes nearly black. Legs chestnut, with anterior tibiae darker. Chelicerae, labium and endites darker, almost mahogany. Abdomen in general silvery white, with a close network of fine brown lines; dorsum typically with four pairs of dark spots of which the most caudal are united; a narrow, brown hastate mark along middle, a brown stripe on anterior face and extending caudad along each side where it bifurcates, a series of oblique lines uniting the two branches in the caudal region; venter covered with a network of dark lines and spots. Anterior row of eyes nearly straight or slightly procurved. Anterior median eyes smaller than the laterals, their diameter or more apart and slightly farther from the laterals. Lateral eyes on each side narrowly separated, obviously closer to each other than in *corollatus*, equal. Posterior row of eyes slightly procurved. Posterior median eyes their diameter apart, nearly twice as far from the equal laterals. The species is easily separable from *I. corollatus*, which it superficially resembles, by the strongly different form of the epigynum as well as by the difference in eye arrangement noted above. See pl. 3, f. 4.

Length, 7.5 mm. Length of cephalothorax, 2.9 mm. Length of tib. — pat. I, 3.4 mm.; of tib. — pat. IV, 3.2 mm.

Type—M. C. Z. 349. Oregon. Portland. S. Henshaw coll., June 19, 1882.

ARGIOPID

Aranea quosquana sp. nov.

Female.—This species falls in the group with longitudinal thoracic furrow, the

anterior femora armed beneath with a double series of numerous stout spines, and the abdomen broadly triangular-oval in outline (*Neoscona* in part.) In coloration it differs from *A. utahana* Chamb., e. g., in having the anterior tibiae and metatarsi only biannulate instead of triannulate, the median annulus being absent, while the femora have an annulus only at the distal end. In the type the carapace is somewhat darkened in a median longitudinal stripe and may have been blackish in life. Thorax blackish at sides. Abdomen in general light yellowish; on posterior portion above a black line with posterior end bifurcating, and a black line on each side also running caudad from anterior end of the median line; on sides a series of brownish, parallel, subvertical lines; venter not unusually black as it is in *utahana*. The scape of the epigynum instead of curving evenly with convexity ventrad, is straight to the distal end which is bent abruptly ventrad instead of curving dorsad as in *vertebrata*. This bending may in part be an artifact as the abdomen in the type was shrunken firmly against the end of the scape. See pl. 6, f. 6.

Length, 14 mm. Length of abdomen, 11.5 mm.; width, 9.6 mm. Length of cephalothorax, 6.6 mm. Length of tib. + pat. I, 7.2 mm.; of tib. + pat. IV, 6.5 mm.

Type—M. C. Z. 388. Cal.: Desert region.

THOMISIDÆ

Thanatus retentus sp. nov.

Female—Carapace with a chocolate colored band on each side above a pale marginal stripe, with a broad median dorsal pale stripe embracing typically a darker median longitudinal mark which bifurcates at the posterior border of head and is continued forward as interrupted dark lines, a median dark line also present between these branches. Lower median region of clypeus pale. Sternum yellow, densely dotted over borders, or sometimes over entire surface, with minute dark spots. Legs brown, lined and mottled with black, the joints showing some clearer longitudinal lines particularly on the femora. Abdomen above yellowish with a dark colored basal sagittate mark reaching to middle or indistinctly continued beyond in an interrupted median line; on posterior region a dark area showing several chevron marks united on each side in a line or band with wavy exterior edge; typically the venter shows two narrowly separated median black lines united in an acute angle in front of spinnerets and ectad of this on each side another dark line. Posterior row of eyes strongly recurved, as usual, the median eyes scarcely nearer to each other than to the laterals (cir. 14:15). Area of median eyes narrower in front than behind, longer than wide in about ratio 20:17. Anterior medians twice as far from each other as from the laterals. Epigynum as shown in pl. 6, f. 5.

Type—M. C. Z. 389.

Claremont. A common species in this region.

This form is readily distinguishable from *coloradensis*, with which it has heretofore been confused, by the obviously different form of the epigynum.

AGELENIDÆ

Agelena rua sp. nov.

Male—Carapace with the sides dark, as usual, the median band yellow. Sternum dusky over yellow with a clear median longitudinal line. Legs light yellow, obscurely

annulate with dark. Chelicerae pale brown. Dorsum of abdomen dark grey along sides, the median region light reddish with a series of yellow spots along each edge; sides of abdomen yellowish grey lightly spotted with black; venter limited on each side by a longitudinal dark line, the intervening region almost immaculate. Posterior eyes equidistant, not fully their diameter apart. Anterior median eyes much smaller than the laterals, near their radius apart, a little nearer to the laterals. Palpal organ represented in pl. 4, f. 1.

Length, ♀ mm. Length of cephalothorax, 3.2 mm. Length of tib. + pat. I, 4.5 mm.; of tib. + pat. IV, 4.7 mm.

Type—M. C. Z. 384. California: Catalina Id.: Avalon Bay. Wm. A. Hilton coll., Aug. 25, 1918.

Distinct from other North American species especially in the structure of the male palpus.

CLUBIONIDÆ

Olios schistus sp. nov.

A species approaching *O. peninsulanus*, known from Lower California, but differing in coloration and various details of structure. While in *peninsulanus* the carapace, labium, endites, chelicerae and legs are uniformly immaculate pale yellow, in the present species the legs are darkened by numerous minute, dark, somewhat purplish, spots which show a tendency to condense into an irregularly defined annulus at proximal end of tibia; similar but fewer dots occur on carapace and chelicerae, but the sternum is immaculate. Abdomen also very obviously darker and differently marked, being densely spotted and streaked on the sides with blackish and less strongly so above and below, the dorsum with a clear sagittate mark at base, followed by a series of short chevron marks united along middle by a black line which is furcate at its anterior end. Anterior eyes obviously larger than the posteriors; anterior median eyes their diameter from the laterals and a little farther from each other, the eyes being more widely separated than in *peninsulanus*. Posterior rows of eyes a little procurved instead of straight, and the eyes much more widely separated than in the species mentioned, the medians being three times their diameter apart and as far or nearly as far from the laterals. Epigynum decidedly larger proportionately, with the outer ridges posteriorly more thickened and elevated with reference to the inner rims, etc. See pl. 4, f. 2. The palpal organ of male of similar structure but obviously heavier; the proximal apophysis of tibia larger, distally clavately expanded and truncate instead of being distally pointed with the setose edge long and oblique; the anterior apophysis also differing as shown in pl. 4, f. 3.

Length of female, 10.5 mm. Length of cephalothorax, 4.8 mm. Length of tib. + pat. I, 6.8 mm.; of tib. + pat. IV, 6 mm. A male with cephalothorax 4.8 mm. long has tib. + pat. I, 8 mm. and tib. + pat. IV, 6 mm. long.

Type—M. C. Z. 354.

Cal. Claremont. R. V. Chamberlin coll. Also Wm. A. Hilton 1918 coll.

Inyphæna crebrispina sp. nov.

Male.—Carapace and legs dull yellow, a dusky band along upper part of each side of the former. Sternum, labium and endites also yellow, the chelicerae brown. Abdomen dull grey of slight yellow cast; dorsum with a few dark spots, the sides with more numerous dark spots and streaks, venter with some spots on posterior portion,

dusky in front of genital furrow. Armature of chelicerae normal. Anterior row of eyes straight; eyes less than their diameter from lower margin of clypeus. Anterior median eyes obviously smaller than the laterals, rather less than their radius apart, closer to the laterals. The lateral eyes on each side their radius apart. Tibiæ I and II armed beneath with three pairs of long spines, the corresponding metatarsi with two pairs. Coxæ of third and fourth and femora of third legs densely spinulose beneath. Furrow of posterior spiracles a little behind middle of abdomen. Palpus pl. 4, f. 4.

Length, 5 mm. Length of cephalothorax, 2.5 mm. Length of tib. + pat., 2.6 mm.; of tib. + pat. IV, the same or nearly so.

Type—M. C. Z. 353. Cal.: Claremont. Pomona College coll.

Anyphæna ruens sp. nov.

Male—Carapace and legs yellowish, the legs with some obscure dusky markings. Sternum, labium and endites yellow. Abdomen yellowish grey; immaculate beneath; streaked and spotted with brown over the sides and the lateral portion of the dorsum; dorsum posteriorly with two or three rows of spots more or less confluent into chevrons, preceded by a pair of spots, the anterior median region of dorsum immaculate. Armature of chelicerae typical. Clypeus not quite as wide as diameter of anterior eyes. Anterior row of eyes straight. Anterior median eyes a little smaller than the laterals, their radius apart, much closer to the laterals. Posterior eyes equal, obviously longer than the anterior ones, the row very slightly procurved. Posterior median eyes their diameter or slightly farther apart. The eyes in general closer together than in *incursa*, those of which they somewhat suggest. Tibiæ I and II armed beneath with two pairs of spines—one pair basal and one submedian—and metatarsi I and II similarly armed, the spines in length from about once and a half to twice the diameter of the joint. Furrow of posterior spiracle rather behind middle of abdomen. Palpus as shown in pl. 5, f. 1.

Type—M. C. Z. 352. Cal.: Claremont. R. V. Chamberlin coll.

Anyphæna zina sp. nov.

Female—Carapace yellow, somewhat darker on the sides, as usual. Legs yellow, marked with a few much interrupted and often obscure annuli, the femora beneath with a longitudinal row of black dots. Sternum, labium and endites yellow. Chelicerae brown. Abdomen yellowish grey; minutely spotted with dark above and over the sides; venter mostly nearly free from spots, but with a dark line from epigynum to furrow of posterior spiracle. Clypeus about as wide as an anterior median eye. Anterior row of eyes a little recurved. Anterior median eyes much smaller than the laterals, not more than their radius apart and much closer to the laterals. Posterior median eyes and anterior laterals about equal in size, the posterior laterals larger. Posterior row of eyes slightly procurved. Posterior median eyes a little more than their diameter apart, a little nearer to the laterals. Lateral eyes on each side more than their radius but obviously less than their diameter apart. Tibiæ I and II armed beneath with three pairs of long spines, none of which are apical. Metatarsi I and II with two pairs of spines beneath. Furrow of posterior spiracle behind middle of abdomen. Epigynum as shown in pl. 4, f. 5.

Length, 6.5 mm. Length of cephalothorax, 2.5 mm. Length of tib. + pat. I, 2.6 mm.; of tib. + pat. IV, 2.7 mm.

Type—M. C. Z. 351. Cal.: Claremont. Wm. A. Hilton coll.

Anyphena incurva sp. nov.

Female.—Carapace dull yellow, darkened over the sides. Sternum, legs, endites and labium yellow. Chelicerae chestnut. Abdomen in general yellowish grey, with a dark stripe along each dorsolateral surface, the two stripes uniting at the spinnerets. Lower margin of furrow of chelicera bearing the usual series of seven or eight small teeth. Anterior row of eyes slightly recurved, the eyes not fully their diameter from the edge of the clypeus. Anterior median eyes only slightly smaller than the laterals, their radius or scarcely more apart and not more than half as far from the laterals. Lateral eyes on each side their radius or more apart. Posterior row of eyes procurved, longer than the first row by about twice the diameter of an eye; eyes subequal to each other and to the anterior laterals. Posterior median eyes nearly once and a half their diameter apart and about their diameter from the laterals. Tibia I armed beneath with two pairs of long slender spines, one pair being basal and one median. Metatarsus with one pair of spines beneath, these basal. Tibia II armed beneath with two unpaired spines corresponding to the posterior members of the pairs present on I. Metatarsus II with a pair of spines at base beneath. Posterior spiracle in front of middle of abdomen. Epigynum as shown in pl. 5, f. 2.

Length, 6.6 mm. Length of cephalothorax, 2.8 mm. Length of tib. + pat. I, 3.2 mm.; of tib. + pat. IV, 2.9 mm.

Type.—M. C. Z. 350. Claremont. Pomona College Coll.

Anyphena mundella sp. nov.

Female.—Carapace yellow of pale brownish cast, a little darkened on the sides. Sternum yellow. Legs of same color as carapace. Abdomen above grey marked with numerous distinct dark dots, which show a tendency to be arranged in transverse series; venter paler, almost immaculate, reddish in front of genital furrow, the epigynum dark. Lower margin of furrow of chelicerae armed with a series of seven or eight small teeth which decrease in size proximad. Anterior row of eyes straight, each removed by more than its radius but less than its diameter from lower margin of clypeus. Anterior median eyes only very slightly smaller than the laterals, their radius or but little more apart but only slightly separated from the lateral on each side. Lateral eyes on each side about their radius apart. Posterior row procurved; eyes very nearly equal in size to the anterior laterals, subequal to each other or the medians scarcely smaller. Posterior median eyes once and a half their diameter apart, very nearly their diameter from the laterals. Tibia I and II and also metatarsi I and II each armed beneath with two pairs of long spines. Furrow of posterior spiracle at middle or slightly behind middle of abdomen. Epigynum as shown in pl. 5, f. 3.

Male.—Palpal organ as shown in pl. 5 f. 4.

Length of female, 6.8 mm. Length of cephalothorax, 2.9 mm. Length of tib. + pat. I, 4 mm.; of tib. + pat. IV, 3 mm.

Type.—M. C. Z. 348.

Cal.: Claremont. R. V. Chamberlin coll. Also Wm. A. Hilton coll., 1918.

Inachemmis gen. nov.

Cephalothorax similar in form to that of *Chemmis*. Anterior row of eyes nearly straight or a little recurved. Anterior median eyes smaller than the laterals. Posterior row of eyes much longer than the anterior row with eyes larger, the medians notably

exceeding the anterior medians, the row typically a little recurved. Area of median eyes narrower in front than behind where the width almost equals the length. Clypeus narrow, not exceeding the anterior eyes. Later eyes contiguous. Labium, endites and sternum essentially as in *Chemmis*, but the lower margin of the furrow of chelicerae armed with three teeth instead of two. The anterior tibiae bear similarly five pairs of long spines beneath; but the metatarsi bear three pairs instead of two. The posterior tibiae bear two median dorsal spines instead of wholly lacking these as in *Chemmis*.

Genotype.—*A. sober* sp. nov.

This genus appears also to include *Chemmis unicolor* of Banks from Arizona in addition to the two species here described. These species are more uniformly colored than the species of *Chemmis*; and, in having all markings nearly obliterated, contrast conspicuously in general appearance with the members of that genus.

Anachemmis sober sp. nov.

Female.—Carapace dusky over a brown to light chestnut ground. Legs light brown to light chestnut, without markings. Sternum light brown or testaceous. Labium and endites darker, pale across distal ends. Chelicerae chestnut. Abdomen dusky brown or blackish, with a median dorsal light line at base extending to near middle, a light spot on each side opposite each end and two or three pairs of light spots farther caudad, but these light marks commonly vague; venter paler, showing a yellowish background darkened by dark spots. Anterior row of eyes nearly straight; the median eyes much smaller than the laterals and especially than the posterior medians, their diameter apart and about half as far from the laterals. Posterior row of eyes a little recurved, eyes subequal; posterior median eyes about their diameter or a little more from the laterals, three-fourths or less their diameter apart. Epigynum as shown in pl. 5, f. 5.

Length up to 10.5 mm. Length of cephalothorax, 4.5 mm. Length of tib. + pat. I, 5 mm.; of tib. + pat. IV, the same.

Cal.: Claremont. R. V. Chamberlin. Paratypes from same region also in collection received from Prof. Hilton.

Anachemmis dolichopus sp. nov.

Female.—Contrasts in general appearance with the preceding species in its very long legs and much lighter color. The carapace, sternum and legs are yellowish brown without markings, but the legs are somewhat darkened over tibiae and distal joints. The abdomen is uniform grey throughout, with no definite markings. The anterior row of eyes slightly recurved; median eyes much smaller than the laterals, about their diameter apart, closer to the laterals. Posterior row of eyes straight; medians smaller than the laterals, about their diameter apart, nearly half as far again from the laterals. Legs very long. Readily distinguishable by the form of the epigynum as shown in pl. 5, f. 6.

Male.—Palpus shown in pl. 5, f. 7.

Length of female, 10 mm. Length of cephalothorax, 4.5 mm. Length of leg I, exclusive of coxae, 17 mm.; of tib. + pat. I, 6.5 mm.; of tib. + pat. IV, the same.

Type—M. C. Z. 344. Cal.: Claremont. Wm. A. Hilton coll.

Namopsilus gen. nov.

Cephalothorax with general form much as in *Trachelas*. Sternum broadly truncate anteriorly, pointed at caudal end, margined. Endites not excavated exteriorly, as broad at middle as at distal end; the distoectal corner rounded. Labium distally truncate or a little incurved. Lateral eyes on each side well separated, though much closer together than the anterior and posterior medians. Anterior row of eyes straight. Anterior medians smaller than the laterals. Posterior row of eyes slightly recurved, eyes equidistant or nearly so and nearly equal in size, with the laterals equal to the posterior laterals. Quadrangle of median eyes wider behind than in front. Clypeus much wider than the anterior eyes. Upper margin of furrow of chelicera with three large teeth, of which the median is longest; lower margin with a series of seven or eight teeth, of which the most proximal ones become reduced in size. None of the legs scopulate and all lacking terminal tenent hairs. Anterior tibiae armed beneath with four pairs of long spines, the metatarsi with three pairs. Posterior tibiae in middorsal line with a basal and a subapical spine, and each patella with a median spine at distal end above, these dorsal spines smaller than the laterals and ventrals.

Genotype.—*N. pletus* sp. nov.

Namopsilus pletus sp. nov.

Female.—Carapace chestnut colored, dusky over the sides, eye region, along striae and over clypeus. Legs light chestnut brown; femora marked with two wide dark annuli, one at distal end and one submedian, these more or less interrupted above; patella with annulus about distal half also interrupted above; tibiae with two broad annuli, one at distal end and one between middle and base, these sometimes almost confluent; entire metatarsi dusky or obscurely biannulate. Sternum light chestnut, the coxae of legs lighter brown. Chelicerae dusky chestnut. Labium and endites pale across tips, elsewhere dark chestnut. Sides of abdomen deep brown or blackish, the dorsum with a series of dark chevron marks ending in the dark of the sides and connected along the middorsal line, the spaces between them on each side yellowish; venter grey. Clypeus twice as high as the diameter of an anterior lateral eye. Anterior median eyes much smaller than the laterals, about their diameter from each lateral eye and considerably farther from each other. Lateral eyes on each side about their radius apart. Posterior row of eyes a little recurved. Posterior median eyes scarcely smaller than the laterals, nearly once and a half their diameter apart and an equal distance from the laterals. Epigynum as shown in pl. 6 f. 1. The spermathecae, which ordinarily show through the integument as black bodies, are not represented in the figure.

Length, 6.5 mm. Length of cephalothorax, 4 mm. Length of tib. + pat. I, 4 mm.; of tib. + pat. IV, 3.7 mm.

Type—M. C. Z. 346. Cal. Claremont R. V. Chamberlin coll.; also Pomona College coll.

TACOSIDAE

Lycosa ferriculosa sp. nov.

Carapace brown, paler in a supramarginal line on each side, below which the marginal dark band is interrupted, and in a median longitudinal stripe which narrows forward and projects in a point between the eyes and again expands between the first and second rows; a curved line each side of the median stripe just caudal of the eyes

Legs testaceous, without markings excepting tibia IV, which is banded at each end with black, and metatarsus IV, which is darkened at the extreme tip. Sternum, coxæ and abdomen beneath solid black. Labium and endites black, pale across tip. Chelicerae brown to bright chestnut. Abdomen above testaceous to yellow with a dark spear-shaped outline over basal part and ending on a chevron mark behind middle, this followed by a few other chevrons; a number of oblique lines extending out from basal mark on each side. A black band across each anterolateral corner and extending along the side where it breaks into streaks and spot; light areas of abdomen clothed with yellow hair. Upper margin of furrow of chelicerae armed with three teeth; the lower margin also with three teeth with are stout and subequal. Anterior row of eyes much shorter than the second, distinctly procurved, median eyes their radius or slightly less apart, an equal distance from the lateral eyes which are decidedly smaller, Lateral eyes scarcely their diameter from lower margin of clypeus, an equal distance from eyes of second row. Eyes of second row less than their diameter apart. Quadrange of posterior eyes comparatively long, the cephalothorax being less than three and a half times as long.

Spines beneath tibiae long and distally very fine. Epigynum small, of form shown in pl. 6, f. 2.

Length, 16.5 mm. Length of cephalothorax, 8 mm. Length of tib. + pat. I, 6.6 mm.; of tib. + pat. IV, 7.5 mm. A male with cephalothorax 8 mm. long has tib. + pat. I, 8 mm. and tib. + pat. IV, 8.5 mm. long.

Cal.: Claremont. R. V. Chambrelin coll.

This species suggests *L. concolor* Banks of Lower California. It is a smaller species distinguishable in having tib. + pat. IV shorter than the cephalothorax instead of clearly longer; in having a black band at both ends of tib. IV instead of only at one end; in not having the femora, metatarsi and tarsi black beneath, etc.

Pardosa tuoba sp. nov.

Female—In the types the body is dark throughout, in life clothed with grey hair; the median dorsal stripe of carapace obscure. Legs black excepting tarsi and metatarsi, which are dull brown, the latter with three black annuli; sometimes the proximal joints also show the paler color in spots and streaks or in part may be somewhat annulate. Sternum solid black. Abdomen with integument black above excepting an obscure pale mark at base; also black laterally, but the venter paler though with a deep black band between epigynum and spinnerets; venter in life clothed densely with grey hairs, the dorsum with grey and reddish intermixed with some black. Anterior row of eyes slightly procurved, much shorter than the second row; median eyes their diameter apart, not fully half as far from the four-fifths as large laterals; the latter twice their diameter from the edge of the clypeus and decidedly more than their diameter from the eyes of second row. Eyes of second row fully their diameter, or slightly more, apart. Two first pairs of spines of anterior tibiae and metatarsi long, slender, overlapping as usual. Armature of chelicerae typical. Epigynum of the *sternalis* type, but with the expanded quadrate posterior end of septum completely filling the posterior cavity, or nearly so, as shown in pl. 6, f. 3.

Length, 6 mm. Length of cephalothorax, 3 mm. Length of tib. + pat. I, 2.8 mm.; of tib. + pat. IV, 3 mm.

Type—M. C. Z. 356. Claremont.

Pardosa hesperella sp. nov.

Female.—Carapace with broad side stripes and narrower supramarginal stripes of chocolate-brown color, the marginal lines black, the eye region also dark; middorsal yellow stripe widest just caudad of eyes with anterior margin straight, from there narrowing caudad, divided anteriorly by a fine median longitudinal black line, the stripe only obscurely indicated between eyes. Sternum black. Legs with femora longitudinally streaked above with black, the joints not annulate or only in part very vaguely so. Abdomen with a yellow basal mark above, this narrow and widening caudad; this mark is edged with black and is followed behind by several black chevron lines; venter light, with no dark markings. Anterior row of eyes straight or nearly so, median eyes their diameter or a little more apart, about half as far from the laterals. Eyes of second row once and a half or more their diameter apart. The epigynum seems clearly distinctive in form. See pl. 6, f. 4.

Length, 7 mm. Length of cephalothorax, 3.5 mm. Length of tib. + pat. I, 3.2 mm.; of tib. + pat. IV, 3.5 mm.

Type—M. C. Z. 392.

Montana. W. M. Mann, collector.

PLATE 1

- Fig. 1. Left male palpus, ectal view, of *Nemesoides hespera*, sp. nov.
- Fig. 2. Left male palpus, ectal view, of *Parauximus tardatus* sp. nov.
- Fig. 3. Epigynum, not fully adult, of *Auximus pallescens* sp. nov.
- Fig. 4. Epigynum of *Auximus latescens* sp. nov.
- Fig. 5. Palpus of *Auximus latescens* sp. nov.

PLATE 2

- Fig. 1. Left male palpus, ectal view, of *Plectreurys suprenans* sp. nov.
- Fig. 2. Epigynum of *Drassodes celes* sp. nov.
- Fig. 3. Epigynum of *Scotophaeus voluntarius* sp. nov.
- Fig. 4. Epigynum of *Herpyllus pius* sp. nov.
- Fig. 5. Epigynum of *Zelotes taibo* sp. nov.
- Fig. 6. Left male palpus, ectal view, of *Zelotes irritans* sp. nov.

PLATE 3

- Fig. 1. Epigynum of *Zelotes gynethus* sp. nov.
- Fig. 2. Chelicera, ectal view, of *Psilochorus californie* sp. nov.
- Fig. 3. Left male palpus, ectal view, of the same.
- Fig. 4. Epigynum of *Lithyphantes mimoides* sp. nov.
- Fig. 5. Epigynum of *Teutana grossa* (C. Koch), a species not uncommon at Claremont.
- Fig. 6. Epigynum of *Agelena pacifica*, var. Claremont.
- Fig. 7. Epigynum of *Agelena californica*, var. Claremont.
- Fig. 8. Epigynum of *Dictyna mians* sp. nov.

PLATE 4

- Fig. 1. Left male palpus, ectal view, of *Agelena rua* sp. nov.
- Fig. 2. Epigynum of *Olios schistus* sp. nov.
- Fig. 3. Left male palpus, ectal view, of *Olios schistus* sp. nov.
- Fig. 4. Male palpus, left ectal view, of *Anyphæna crebrispina* sp. nov.
- Fig. 5. Epigynum of *Anyphæna zina* sp. nov.

PLATE 5

- Fig. 1. Right male palpus, ectal view, of *Anyphæna ruens* sp. nov.
- Fig. 2. Epigynum of *Anyphæna incurva* sp. nov.
- Fig. 3. Epigynum of *Anyphæna mundella* sp. nov.
- Fig. 4. Left male palpus, ectal view, of the same.
- Fig. 5. Epigynum of *Anachemmis sober* sp. nov.
- Fig. 6. Epigynum of *Anachemmis dolichopus* sp. nov.
- Fig. 7. Right male palpus of the same.

PLATE 6

- Fig. 1. Epigynum of *Namopsilus pletus* sp. nov.
- Fig. 2. Epigynum of *Lycosa ferriculosa* sp. nov.
- Fig. 3. Epigynum of *Pardosa tuoba* sp. nov.
- Fig. 4. Epigynum of *Pardosa hesperella* sp. nov.
- Fig. 5. Epigynum of *Thanatus retentus* sp. nov.
- Fig. 6. Epigynum of *Aranca gosogana* sp. nov.

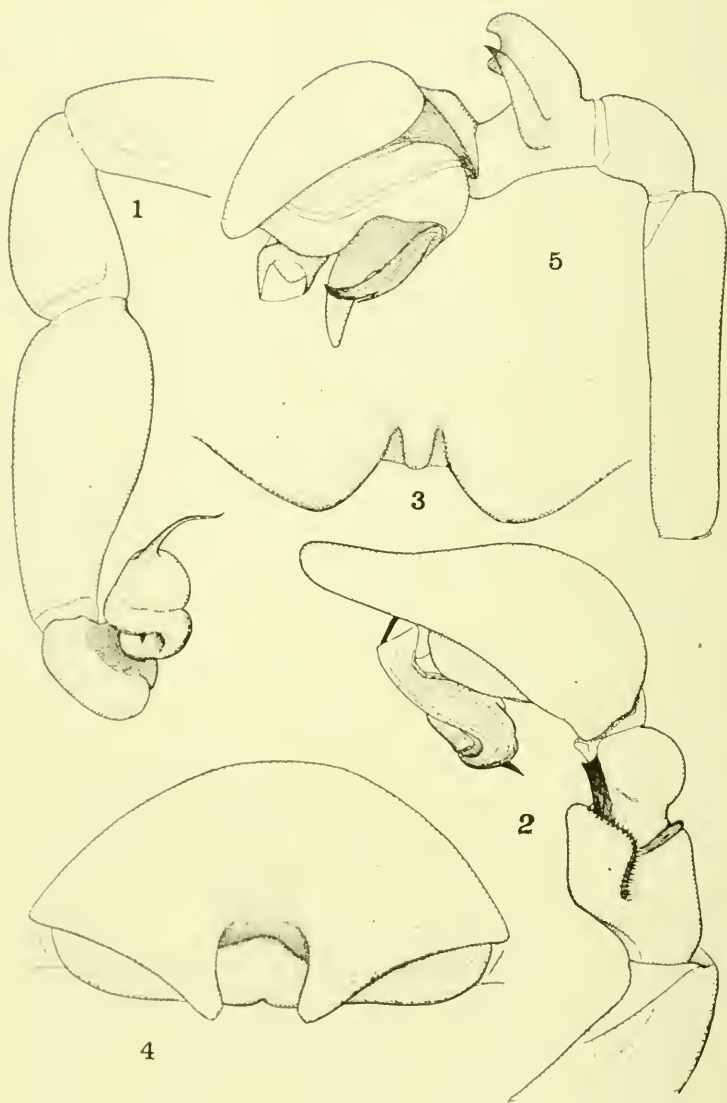
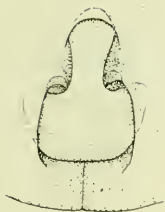
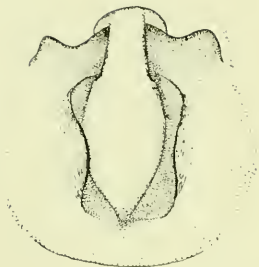


PLATE I

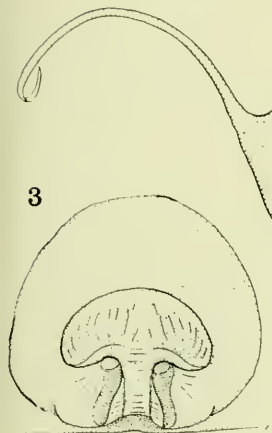
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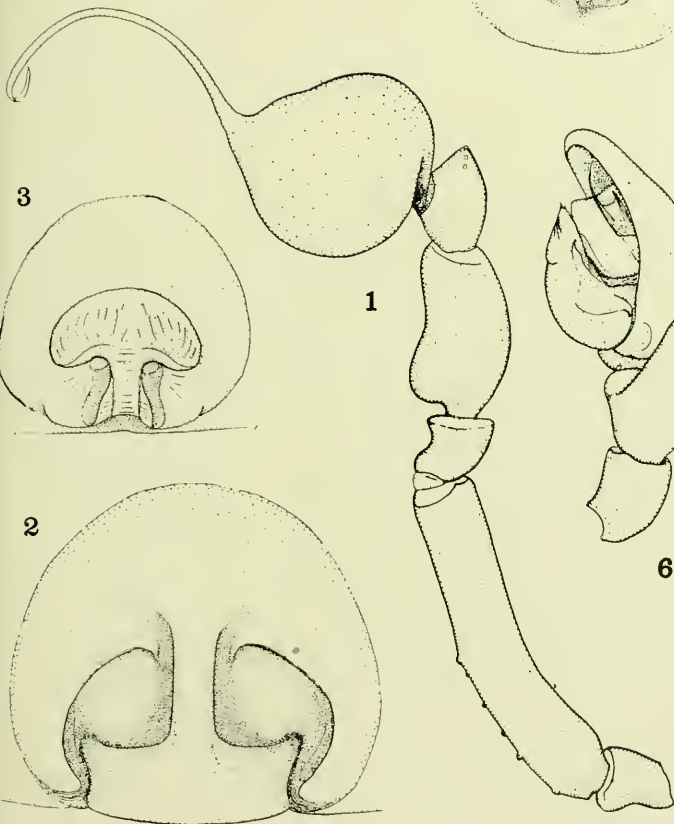
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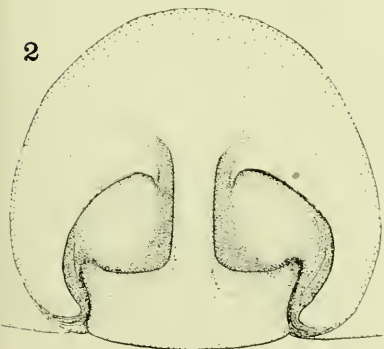
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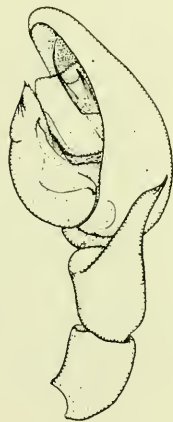
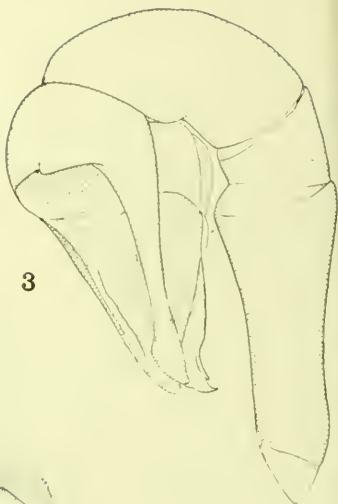


PLATE II

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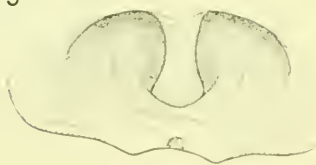
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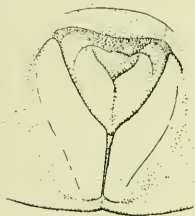
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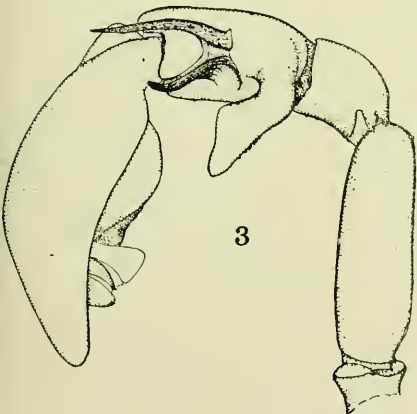


PLATE IV

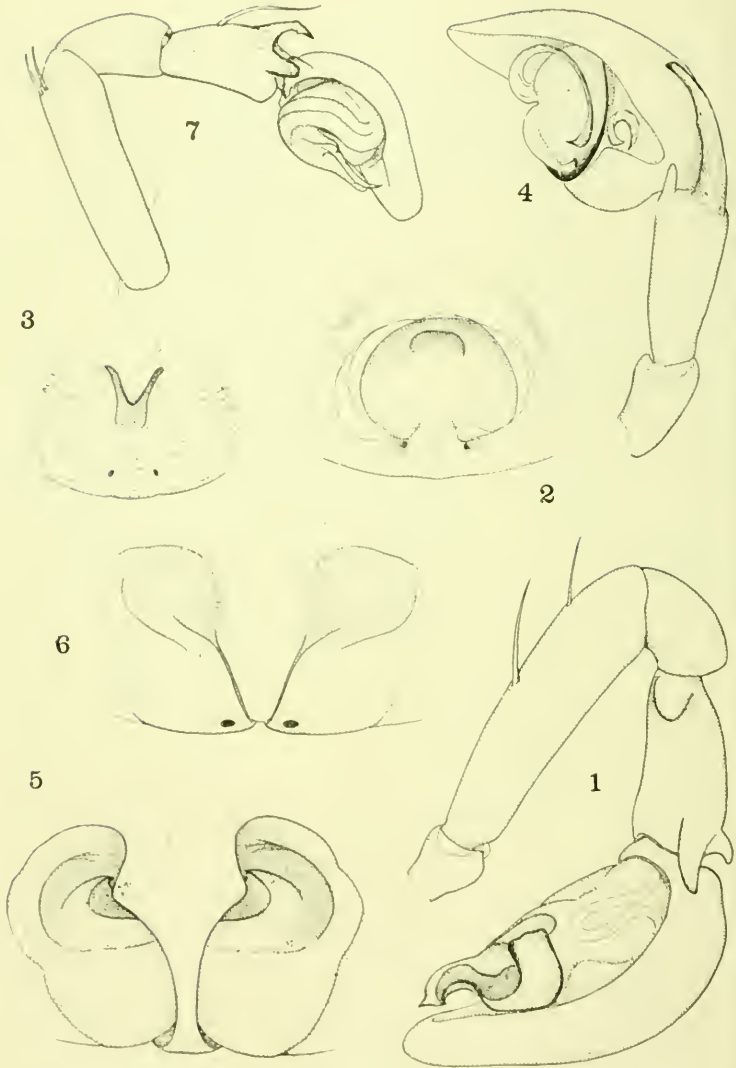
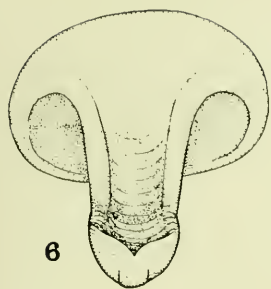
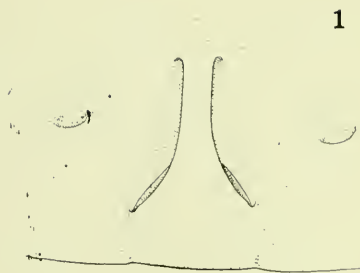


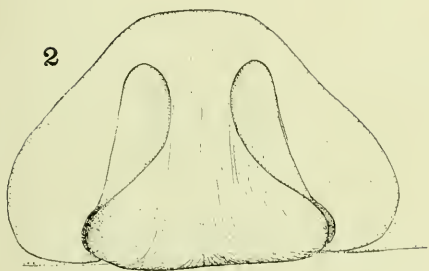
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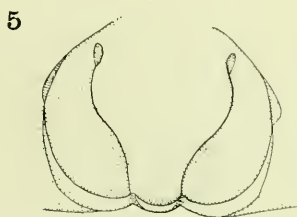
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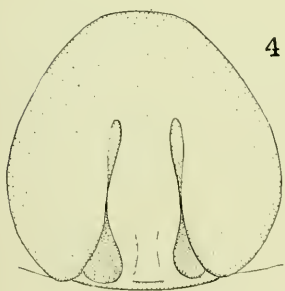
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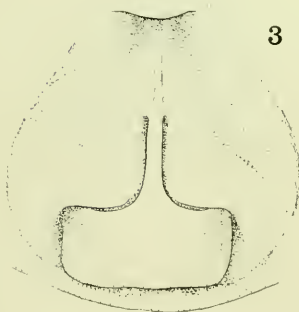
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3

Centipedes and Millepedes from Near Claremont

Most of the specimens were collected during the past few years. All but the *Scutigera* were determined by Dr. R. V. Chamberlin.

CENTIPEDES

SCOLOPENDROMORPHA

Scolopendria polymorpha Wood. The largest local form and one of the most common.

Otoerythroptops gracilis (Wood). A smaller form which is also common.

GEOPHILOMORPHA

Clinopodes limatus (Wood). A species more commonly listed under *Mecistocephalus* sens. lat.

Nyctunguis heathi catalinae (Chamb.)

Linotania levipes (Wood). This bright red species is found especially in the mountains.

Geophilus rubens Say.

Geophilus regnans Chamb. Very common.

Trenophilus bipuncticeps (Wood).

Fairyuna occidentalis Meinert.

T. claremontus Chamb.

Tabiphilus rex Chamb.

Notobius tenuispis (Wood). A long species with 129 to 149 pairs of legs.

Gosiphilus bakeri Chamb.

Gosiphilus laticeps (Wood).

SCUTIGEROMORPHA

Scutigera forceps Raf. From houses.

LITHOBLOMORPHA

Lamyctes pinampus Chamb.

Ethopolys xanti (Wood).

Gosibius paucident (Wood). Common.

Irbis elysianus Chamb.

Nothembius nampus Chamb.

Pokabius clavigerens Chamb.

MILLEPEDES

The species described by Chamberlin were described in the Proceedings of the Biological Society of Washington in December, 1918, Vol. 31, pp. 165-170.

Paranulus furcifer Hag.

Tylobolus claremontus Chamb.

Hiltonius pulcherrus Chamb.

Atopetholus californicus Chamb.

A. parvus Chamb.

Spiders from the Claremont-Laguna Region

The following is a list of spiders collected during the past few years. All the determinations were made for us by Dr. R. V. Chamberlin. None of the new species recently described by Chamberlin are included in this list.

AVICULARIIDÆ

Bothriocyrtum californicum (Camb.)

ULBORIDÆ

Uloborus californicus Bks. Uplands, 1200 ft. Nicholson.

DICTYNIDÆ

Dictyna calcarata Bks.

SCYTODIDÆ

Plectreurys castanea Sim.

DRASSIDÆ

Zelotes maculata Bks.

Herpyllus validus Bks.

H. angustus Bks.

PHOLCIDÆ

Physocyclus globosus Tac. Uplands Nicolson.

Pholcus phalangioides Fuessl.

AGELENIDÆ

Agelena pacifica Bks.

A. californica Bks. Claremont and interior of Catalina.

A. norvia Hentz. Claremont and Avalon, Catalina.

Tegenaria domestica Clerck.

T. californica Bks.

Chorizomma californica Simon.

LINYPHIIDÆ

Liphia Sp.

ARGIOPIDÆ

Cyclosa conica Pallas. Cucamonga Mt. 4500 to 5500 ft. Johnston.

Araneae miniata Walck.

A. curcurbitina Clerck.

A. marmorea Clerck.

A. angulata Clerck.

Metargiope trifasciata Forsk.

Zilla X-notata Clerck.

Tetragnatha laboriosa Hentz.

THERIDIIDÆ

Tentana grossa C. Koch.

Latrodectus mactans Fabr.

Theridion tepidariorum Koch.

THOMISIDÆ

Thanatus coloradensis Keys.

Xysticus californicus Keys.

X. ferox Hentz.

Misumena vatia Clerck.

Misumenoides aleatorius Hentz.

Misumenops asperatus Hentz.

Philodromus pernix Black.

P. moestus Bks.

CLUBIONIDÆ

Chiracanthium inclusum Hentz.

Trachelas tranquilla Hentz. Claremont and Catalina.

Castianeira pacifica Bks.

Gayenna Juv.

Inyphocna Juv.

LACOSTIDÆ

Lycosa kochii Kevs. Claremont and Ontario Mt. 6000 to 7000 feet.

Lycosa, near *carolinensis*, not quite mature.

Pardosa sternalis Thorell.

P. lapidicina Em.

P. californica Kevs.

Pardosa sp. Catalina interior. Claremont.

Central Nervous System of *Mytilus Californianus*

WILLIAM A. HILTON

The cerebral ganglia are well separated from each other, but the smallest of the three groups of ganglia in the nervous system. A large cephalic branch goes to the palps, smaller lateral ones supply adjacent parts in the mouth region. No attempt was made at this time to follow peripheral branches very far.

The single mass of the pedal ganglion may be easily seen to be composed of a right and a left half. The pedal connections with the main trunk are somewhat smaller than the long connectives and hardly larger than some of the other branches of the ganglion, notably the large lateral caudal branches. The caudal branches of the pedal are chiefly three on each side, the more lateral being very large and the medial the smallest. They penetrate and supply the foot and viscera.

The visceral ganglia are more widely separated than the cerebral and much larger. The large caudal branches pass over the posterior adductor muscles to become supplied to the muscle and to the mantle. The smaller lateral branch runs out laterally dividing soon into two to supply the gills.

In the cerebral ganglion the fibers form a broad connection across the middle line. There are a few cells along the course of the commissure. Nerve cells are found inclosing the central fibrous mass. The cells are three or four layers thick except at certain places where there are none. The cells are of several sorts: First—those that stain deeply with hematoxylin. Some of these may be neuroglia cells, they are rather small cells and some seem to have very little cell body; second—large cells with clear protoplasm with distinct fibrillar structure. The processes of these are long, in some cases may be followed for some distance; third—there are some very small cells that do not stain deeply. These may some of them be neuroglia cells, others may be nerve cells in some special physiological condition.

In the fibrous areas of the ganglia, larger and smaller strands are evident, with only a few cells in central portions.

The cell areas about the cerebral ganglion differs slightly at various points, but there is no marked massing into groups.

The pedal ganglion, like the cerebral, has a central fibrous core covered with a rather even mass of cells of large and small size, but the cephalic and caudal regions have the thicker masses of cells. The ventral sides of the pedal has more cells than the dorsal. Two sides of the ganglion are well marked from each other, although broadly connected by fibers.

The large visceral ganglia are more complicated in structure than the others, but a similar general arrangement of cells is found.

The peripheral distribution of nerves was not followed at this time. For the general anatomy of bivalves one of the most recent works gives a detailed account of peripheral distribution in a bivalve:

Splittstosser, P., 1913.

Zur Morphologie des Nervensystems von *Anodonta cellensis* Schrot. Zeit. f. wiss. zool. Bd. CIV 3 heft.

(Contribution from the Zoological Laboratory of Pomona College.)

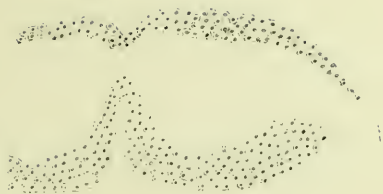
Explanation of Figures

Fig. 1. Central ganglia of *Mytilus*. The cerebral ganglia are above in the figure. X6.

Fig. 2. Longitudinal section of the cerebral ganglion of *Mytilus*. The connective end is down. X70.

Fig. 3. Cross section of the cerebral ganglion of *Mytilus*. The dorsal side is up. X70.

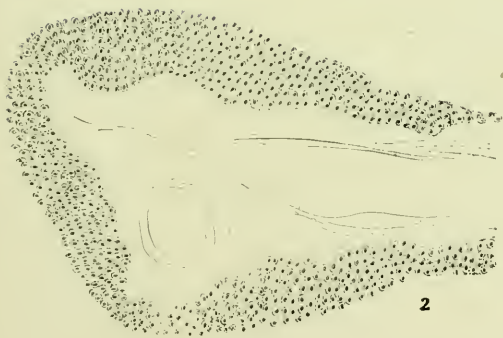
Fig. 4. Cross section of the pedal ganglion of *Mytilus*. The dorsal side is up. X70.



4



3



2



1

Notes on the Sipunculida of Laguna Beach

RALPH A. CHAMBERLIN

The following notes and provisional diagnoses are based upon a collection of Sipunculids made by Prof. Hilton at Laguna Beach in 1917. Six species are represented.

SIPUNCULUS NUDUS LINN.

One specimen of this widespread species was taken on the sand flats at low tide in August, Balboa. As preserved it is 26 cms. long. Attachments of nephridia and retractor muscles normal. The usual 31-32 longitudinal muscle bands. The body appears to be pigmented to some extent, as has also been recorded for a specimen from the Malacca region described as dark brown (Selenka), and one from Key West (Gerould). The species is known from various parts of the Atlantic along both shores, from the Mediterranean, Adriatic and Red seas, Malacca, Bismarck Archipelago, Philippines and Japan.

PHYSOSOMA AGASSIZII KEFFERSTEIN

In the collection are six specimens of this well-marked species taken at low tide on sand flats at Balboa and Laguna Beach. The species is otherwise known to occur along the California coast (e.g., at Monterey Bay, Mendocino, San Francisco, Crescent City) and northward (Vancouver Id.) as well as southward (Puntarena, Panama). It has also been taken at Loyalty Is., Ceylon, Laccadives and Maldives, and in the Atlantic on the coasts of the United States and Africa.

DENDROSTOMA ZOSTERICOLA SP. NOV.

This species belongs to the group with but two retractor muscles. These have their origins in the posterior third of the body (in the type about 10 mm. from caudal end) and are well developed throughout and free to near insertions. The nephridia open at the level of the anus and are elongate and free. Contractile tube with numerous caeca. Tentacles strongly dendritic or arborescent, the terminal branches numerous. Introvert wholly lacking hooks. Skin brown or in part grey, set off into numerous areas, these transversely elongate in middle region, in the posterior more rectangular and longitudinally elongate. Entire body and introvert, excepting a short area proximal of tentacles, bearing moderately numerous, small, dark and rounded elevations which do not rise into true papillae; usually one of these to each cuticular area; of uniform size and abundance throughout. Body typically narrowed at both ends, fusiform. 35 mm. long behind anus and about 15 mm. to distal end of introvert.

Taken in eel grass in September, 1917.

Type—M. C. Z. 2, 181

DENDROSTOMA MYTHICA SP. NOV.

The type of this species was found in eel grass. Zosteræ in the same original lot with the types of the preceding species. It is a smaller species of obviously different form. The body is widest at the posterior end, followed by a much longer, narrower,

subcylindrical portion extending to the still narrower introvert proper. The species is like *zostericola* in lacking hooks on the introvert, but differs obviously in the character and arrangement of the tubercles. These are similarly small over the general body but are more closely arranged over the middle region than over the broader posterior one, while particularly characteristic is a band of abruptly much larger tubercles about the base of the introvert, distad of which region they become again abruptly smaller. The color is brown. The two retractors are inserted at the anterior end of the broad posterior region and are fused anteriorly, their free portions short. Nephridia free.

Length of body behind anus, 12 mm.; in front of this to base of tentacles, near 8 mm.

Type—M. C. Z. 2, 184.

DENDROSTOMA PYROIDES SP. NOV.

Differing conspicuously from *zostericola* in form, being broadest at the posterior end and as a whole subpyriform instead of conspicuously fusiform. It is darker brown in color. A conspicuous external difference is in having the introvert, or proboscis, armed on its median portion with numerous, comparatively large, dark hooks, which are not definitely seriate. The cuticle in general is covered with numerous small, dark, rounded elevations which in surface view are circular to slightly elliptic in outline and are larger in size at the base of the proboscis and at the posterior end of the body than elsewhere. Tentacles arborescently branched, the terminal branches numerous, finger-like. The two retractors are stout bands taking their origin in the posterior third of the body. Contractile tube with fewer caeca. Nephridia free, opening a little farther forward than the anus.

Length from anus to caudal end, 17 mm.; from anus to base of tentacles, 8 mm.

Taken at low tide on Laguna Beach.

Type—M. C. Z. 2, 182.

PHASCOLOSOMA HESPERA SP. NOV.

Somewhat resembling *P. procerum* in form, but with the proboscis more abruptly set off from the body and on the average narrower and especially much longer relatively to the latter. In the type the body proper is 8.5 mm. long, while the proboscis is 52 mm. long, i. e., about six times longer than the body, while in one paratype it is as much as 7.5 times longer. The body of the type is 2.6 mm. thick and the proboscis half or less than half this thickness. Body proper pointed at both ends, broadly subfusiform. The skin at the caudal end of the body is rather thickly studded with papillae, which are disally flat and dark colored over a pale and often constricted base. The papillae rapidly become fewer and more widely scattered over the middle and anterior regions of the body and over the proboscis, and at the same time become decidedly smaller and are often borne singly on low, rounded elevations; on the proboscis the papillae are typically colorless. The two retractor muscles in the type have their origins in the anterior part of the body.

The type was secured in sand at Balboa, December 26, 1917. Paratypes from eel-grass on Laguna Beach, September, 1917.

Type—M. C. Z. 2, 185.



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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor

Claremont, California, U. S. A

A Study of the Food Habits of the Ithacan Species of Anura During Transformation*

PHILIP A. MUNZ of Pomona College, Claremont, California

In recent years almost as much interest has been attached to the study of the habits of animals and to the relation to the environment as to the structure and classification. Naturally enough the food-habits are among those that can be most profitably studied; as an example I have to cite only the work of Professor S. A. Forbes of the University of Illinois on the food of fresh-water fishes. His results, embodied in a series of papers published by the Illinois State Laboratory of Natural History, have been very suggestive and an inspiration to investigation in allied groups. When, therefore, a study of the food-habits of various species of the Anura during their transformation period was suggested to me, it was gladly taken as a subject of some promise.

The purpose of the investigation was to learn something more definite than was already known concerning the food before and after transformation and to see how the change from the one kind to the other came about. It was thought that such knowledge might aid to some extent in frog-culture during this rather critical period of a frog's development.

The problem was undertaken with the advice and criticism of Doctor A. H. Wright of Cornell University. To him my sincere gratitude is hereby given, not only for his suggestion of the problem and for his help in carrying it out, but for the abundant material which he so generously put at my disposal and which was the result of much careful collecting on his part.

Largely because of the work he had been doing at Ithaca during the last ten years, material was available for all eight species of Anura occurring in the Cayuga Lake Basin of New York state. In all, 586 specimens were dissected, giving a fairly representative series for each of the species which were as follows:

Rana catesbeiana Shaw. The Bullfrog.

Rana clamitans Latreille. The Green-frog.

Rana sylvatica Le Conte. The Wood-frog.

Rana palustris Le Conte. The Pickerel-frog.

Rana pipiens Schreber. The Leopard- or Meadow-frog.

Hyla crucifer Wied. The Peeper.

Hyla versicolor Le Conte. The Tree-toad.

Bufo americanus Holbrook. The Common Toad.

METHODS

As specimens were collected in the field they were immediately killed, usually in formalin, in order that digestion would immediately cease. Each lot that was col-

A contribution from the Zoological Laboratory of Cornell University of Ithaca, New York.

lected was kept separate and the data as to its time and place of collection were recorded. This data can be found under the discussion of the individual species. My part in the collecting was during the season of 1916, and during the following fall and winter the material was examined.

As complete information as possible was secured as to the stage of transformation; the length of the tail, condition of the mouth, length of the alimentary canal, its differentiation into stomach, small and large intestines, and the development of the front legs—all these facts were noted. Unfortunately at first the desirability of so complete a record was not realized and the bullfrog, which was the first species studied, did not receive as full treatment as those taken up later.

After the alimentary canal had been removed and its length had been measured, the contents were removed and identified. In many cases, perhaps a more exact determination of the forms found could have been carried out by specialists, but the kind of food rather than the exact species seemed the essential thing. For this reason a not very serious attempt was made below the identification to family, especially where digestion had proceeded to any extent.

WORK PREVIOUSLY DONE

Some very thorough investigation has been carried out on the food of the adults of several species, in America the most notable being that of Kirkland on the American toad, and of Drake on the meadow-frog. Kirkland¹ in an examination of 149 toad stomachs which had been collected in a number of situations, found that by bulk 98% of the food examined was animal, that 77% was made up of insects and, that of the insect food 11% was of beneficial forms, 22% neutral and 62% injurious. He made note, too, of the fact that the toad feeds largely at night and that in a single twenty-four hours it can fill its stomach to its complete capacity four times. He said, too, that the toad takes only living and moving forms; this fact is one repeated by other observers for other species of the Anura and agrees with my own results. As an example of the evident attractive power a moving object has for an Anuran I may mention a specimen in the Museum of the University of Denver. It is a toad probably of the Woodhouse variety, which was brought in dead and dried up and with the tip of a turkey wing projecting from the mouth. It had evidently been attracted by the small bunch of feathers being blown about and, having swallowed a part was not able to finish the process nor to disgorge because of the barbs of the feathers catching in the throat.

From the tables given by Kirkland one is led to infer that practically no aquatic forms enter into the toad's diet, a not very surprising fact when its terrestrial habits are remembered. Since many aquatic insects are attracted to electric lights, it is evident that a toad or frog feeding under the corner arc light can secure such forms without ever approaching water.

¹Kirkland, A. H., 1897. Habits, food and economic value of the American toad. (Bull. 46 of Hatch Exp. Station of the Mass. Agric. College, 1904). Usefulness of the American toad. (Farmer's Bull. 196, U. S. Dept. of Agriculture.)

In addition to the work of Kirkland some other work has been done by Garman² on the toad in Illinois and Kentucky, and has had in large part the same results, showing that many harmful insects are destroyed.

The work of Drake³ mentioned above and dealing with the meadow-frog covered an examination of 209 stomachs. Mr. Drake says, "All the evidence indicates that the presence of substances other than those of an animal nature is merely incidental, and due to the mode and conditions of feeding," and "Nothing can be more natural, since the frog captures the greater part of its prey on the ground by means of its tongue, than that a small amount of foreign substances should be swept into the mouth along with the animals upon which it feeds. The frog's food consists of mollusks, crustaceans, myriapods, spiders and insects; in fact any sort of living creature is acceptable to it as both sense of taste and of smell are apparently obtuse."

In his work at Saranac Inn in the Adirondacks, which is reported in the "Mayflies and Midges of New York," Professor Needham⁴ spent some time in a study of the summer food of the bullfrog and in his report gives the contents of 16 stomachs. Of the 164 animals found 139 were insects, 18 were snails, three crustaceans, three spiders and two vertebrates, one bullfrog tadpole, and one meadow mouse. This assemblage differs largely from the food of the toad in that many aquatic forms are reported, some of which must have been taken under water, for example the nymph of the mayfly *Siphylurus alternatus* Say, which Professor Needham says never comes to the surface except for transformation. Other forms were the *Rana* tadpole, *Anax* nymph, chironomid larvæ, and a small copepod and some aquatic snails; while the water-striders, soldier-fly larvæ (Stratiomyidæ), gnat pupæ and transforming caddisflies taken were probably secured at the surface of the water.

The few others who have studied the food of the bullfrog have likewise found many vertebrates eaten. Brakeley⁵ in twelve bullfrogs dissected found one mouse, one young bird, one frog, two toads, two carp, six mud-fish, one mud-turtle, besides of course, many insects and other invertebrates. Dyche's report⁶ in 1914 on the contents of 30 bullfrog stomachs substantiates previous reports on the greed and rapaciousness of this species. He found that one specimen thirteen inches long had swallowed another about ten inches long and cites many other cases of cannibalism. Fourteen of his 30 species contained 32 fish, otherwise the diet was made up largely of crayfish, other crustaceans, insects, spiders and snails.

Brief mention of the feeding habits of the species of *Anura* is made by Miss Dickerson⁷ who has evidently based some of her account on personal observation. Of especial interest here are remarks on the food of tadpoles. Concerning the tadpole of the toad she says, "These mouths are provided with horny jaws for scraping the tiny plants from their supports and for biting off the delicate ends of larger plants." In another connection, "The tadpoles of the wood-frog eat not only the green jelly mass from which they themselves hatch, but also the soft green spheres within the jelly masses vacated by young salamanders. Like other tadpoles, they

²Garman, H., 1901. The food of the toad. (Bull. 91, Agric. Exp. Station of Kentucky.)

³Drake, C. J., 1904. The food of *Rana pipiens* Shreber. (Ohio Naturalist, 14:257-269.)

⁴Needham, J. G., 1905. The summer food of the bullfrog (*Rana catesbeiana* Shaw) at Saranac Inn. (Bull. 86, New York State Museum.)

⁵Brakeley, J. H., 1885. Notes on carp and frog-culture. (Bull. U. S. Fish Com., 5:209-213.)

⁶Dyche, L. L., 1914. Ponds, pond fish, and pond fish culture. (Bull. No. 1 of Dept. of Fish and Game, Kansas.)

⁷Dickerson, Mary C. The Frog Book. (Doubleday Page and Co.)

act as scavengers by greedily devouring all dead animal matter of the pond." For the bullfrog tadpole she says, "The mouth is well fitted to bite the delicate ends of leaves and stems, or to scrape off the tender green or brown plants from sticks and stones. It is equally adapted for eating animal food. The bullfrog tadpole (like that of the green-frog and that of the wood-frog), is especially fond of any animal food available. Thus these tadpoles act as scavengers and dispose of dead fish or dead tadpoles even, that otherwise would become a menace to the living creatures of the pond."

Her remarks on the food of the adults bear out the statements made by other workers and show further that the bullfrog and the green-frog are the most aquatic of the eastern frogs, that the meadow- and pickerel-frogs are less so, while the wood-frog, peeper, tree-toad and common toad are even less inclined to be found in the water. The food is therefore expected to vary accordingly.

Her observations on moulting the skin are also of interest. "The green-frog moults the skin four or more times each year. If the frog is out of the water when the moulting takes place, the process is like that of the American toad and of the leopard-frog, and the skin is swallowed. If the moulting takes place in the water the skin may float off in large patches and is not eaten."

From this short review of the literature in regard to the food of the Anura of this country, it can readily be seen that there are many statements as to the food of the adults and some remarks are even made as to that of the tadpole, but I have found nothing as to food during transformation, except that the tail is absorbed by phagocytic action and is used. It shall therefore be my attempt in the following pages to take up in more detail the food of the adult tadpoles, of the transforming ones, and of the young frogs.

GENERAL DISCUSSION OF TRANSFORMATION

One of the first evidences externally of transformation and the one most greatly affecting the food situation is the shedding of the horny plates characteristic of the tadpole's mouth. After this takes place the alimentary canal decreases to one-tenth or one-twelfth of its larval length, and at the same time becomes differentiated into distinct portions. The larval digestive tube is merely a long tube, that of the young frog has a widened and thick muscular-walled stomach, a long narrow small intestine, and a much shorter but likewise thin-walled large intestine. In the specimens dissected the longest larval alimentary tract found in the bullfrog was 1070 mm., the average after decrease in length was from 85 to 95 mm.; for the green-frog the two measurements were 450 and 50 to 60 respectively, for the wood-frog 200 and 18 to 20, for the pickerel-frog 400 and 30 to 35, for the meadow-frog 530 and 30 to 40, for the peeper 88 and 10 to 15, for the tree-frog 170 and 15 to 18, and for the toad 110 and 10 to 15. While all this change is going on the mouth is gradually increasing in size to one many times larger than the tadpole mouth. Obviously while the mouth is still very small it is scarcely capable of taking in any food, its horny plates having been lost. In order that the materials eaten may be swallowed whole and not nibbled off, the mouth has to be considerably enlarged. It is not strange then, to find that without exception all eight species go through a period of fasting as far as taking food from the outside is concerned. An examination of the data

given under the separate species will show that many of the individuals studied, and practically all of these in which the mouth was enlarging, contained no food. It seems hardly necessary to say in this connection that the absorption must make possible this period of fasting.

It must take some little time for the food to pass through the long alimentary canal of the larva, since it was quite noticeable that in many of those examined in which the mouth plates had recently been shed, the caudal portion still contained the mud and other contents typical of the larva and which had probably been taken into the body when the mouth plates were still in place.

The length of the body without considering the tail, remains almost unchanged during transformation, but the rotund aspect of the tadpole gives way to the flatter and more angular one of the young frog. The appearance of the front legs, the left one coming out through the spiracle and the right one breaking through the skin, as well as the shrinking of the tail are further indications of the progress made in transformation. Usually the tail is almost gone before feeding as a carnivor begins.

It is to be noticed that in the data given for the bullfrog almost every transforming individual is reported as having swallowed some of its own cast epidermis. This is true to a lesser degree of the other species, probably because the much smaller size of such species as the tree-toad and the toad makes the recognition of epidermis in the alimentary tract of preserved specimens more uncertain. The frequent occurrence, one might say almost universal occurrence, of epidermis in transforming individuals must mean frequent moulting. Doubtless this is true, especially of the tail, which shrinks rapidly and might naturally shed its epidermis. That the shedding of the skin takes place in the water is evidenced by the threads of *Spirogyra* and *Zygnema* often wrapped up in it as if during seizing and swallowing.

The discussion of transformation may be concluded, then, by saying that it is accompanied by a period of fasting during which time, in all eight species, the food-getting and food-assimilating apparatus is rebuilt and changed from one suitable to a form largely herbivorous and at least feeding only on dead animal material, to one which will permit of the predaceous and carnivorous habits of a frog or toad.

PRESENTATION OF DATA FOR THE SPECIMENS EXAMINED

In the following pages lists are given of the specimens dissected with data showing the degree of transformation and the contents of the alimentary canal. The word "stomach-content" is not sufficient here; for in many cases the stomach was almost empty while the large intestine contained large amounts of food; in the case of insects, passage through the digestive tract in this way had not sufficiently changed many specimens to make it impossible to identify them to family at least. In the data given under each species, "No." refers to the number of the specimen, "Body" to the length in millimeters, measuring from the tip of the head to the base of the tail; "Tail" to the length of the tail in millimeters, "Mouth" to the condition of the mouth, whether that of the tadpole with the horny plates or with these shed, or with the mouth enlarged; "Ali. Can." to the length in millimeters and to the condition of the alimentary canal; "Fore Legs" to the presence or absence of the front legs; "Lot" to the lot to which the particular specimen belonged, and "Food" to the material found in the digestive tract.

Rana catesbeiana Shaw. The Bullfrog.

Total of 104 specimens. Lot 1, Dr. A. H. Wright and Dr. A. L. Leathers, Wood's Hole, Mass., July 16, 1909. Lot 2, Wright and myself, July 10, 1916, Dwyer's Pond, Ithaca; lot 3 same, but on July 17. Lot 4, Dr. Wright, July 7, 1911, Beaver Brook Mill Pond, Ithaca.

Table 1. Data for *Rana catesbeiana*

No.	Body	Tail	Mouth	Age	Color	Fore Legs	Lot	FOOD
1	48	87	tadpole	1670, tadpole		none	4	Mud with Meridion, Cymbella, Navicula, Diatoma, Frustulia, Pinnularia, Oscillatoria
2	45	95	tadpole	980, tadpole		none	4	Mud with Epithemia, Navicula, Pinnularia, Diatoma, Synedra, Nitzschia, Cymbella, Meridion, Ulothrix, Spirogyra, Oscillatoria
3	51	118	hanging	240, stom. small		present	2	Green algal threads
4	51	115	tadpole	140, stom. small		"	2	Greenish material, not identifiable
5	51	75	changing	190, stom. & int		"	2	Epidermis, Spirogyra, Zygnema
6	50	85	small	115	" "	"	2	Epidermis, Spirogyra
7	55	85	"	" "	" "	"	1	Nothing
8	55	85	"	" "	" "	"	2	Epidermis, Spirogyra
9	50	80	"	165	" "	"	1	Epidermis
10	53	70	"	"	" "	"	1	Nothing
11	54	70	"	"	" "	"	1	Nothing
12	50	70	"	"	" "	"	1	Nothing
13	57	68	"	110, stom. & int	" "	"	1	Epidermis
14	52	68	"	"	" "	"	1	Epidermis, piece of plant tissue
15	53	65	"	100	" "	"	1	Epidermis
16	51	65	"	"	" "	"	1	Epidermis, Insecta 1
17	52	64	"	"	" "	"	1	Epidermis
18	50	60	"	100, stom. & int	" "	"	1	Epidermis
19	48	60	"	"	" "	"	1	Epidermis?
20	51	60	"	stom. & int	" "	"	1	Epidermis?
21	53	58	"	94	" "	"	1	Epidermis
22	50	57	"	85	" "	"	1	Epidermis
23	52	55	"	95	" "	"	1	Epidermis
24	53	55	"	97	" "	"	1	Epidermis, some plant tissue
25	51	52	"	"	" "	"	1	Nothing
26	45	52	"	78, stom. & int	" "	"	1	Epidermis
27	51	52	"	88	" "	"	1	Epidermis
28	50	50	"	"	" "	"	1	Epidermis
29	50	50	"	"	" "	"	1	Nothing
30	52	50	"	"	" "	"	1	Epidermis
31	52	50	"	stom. & int	" "	"	1	Epidermis?
32	55	48	"	"	" "	"	1	Epidermis
33	54	48	"	"	" "	"	1	Epidermis
34	52	47	"	stom. & int	" "	"	1	Epidermis
35	50	46	"	"	" "	"	1	Epidermis
36	54	46	"	stom. & int	" "	"	1	Epidermis?
37	50	45	"	"	" "	"	1	Epidermis
38	51	45	"	115, stom. & int	" "	"	1	Epidermis
39	52	45	"	"	" "	"	1	Epidermis
40	49	45	"	stom. & int	" "	"	1	Epidermis
41	53	43	"	95	" "	"	1	Epidermis
42	49	43	"	96	" "	"	1	Epidermis, sand, moss leaves
43	53	43	"	"	" "	"	1	Epidermis
44	51	40	"	90	" "	"	1	Epidermis
45	51	40	"	85	" "	"	1	Epidermis, some plant tissue
46	51	40	"	"	" "	"	1	Epidermis
47	50	40	"	85, stom. & int	" "	"	1	Epidermis, Collembola 1
48	51	40	"	"	" "	"	1	Nothing
49	51	38	"	stom. & int	" "	"	1	Epidermis
50	51	37	"	"	" "	"	1	Nothing
51	51	35	"	"	" "	"	1	Epidermis
52	51	35	"	"	" "	"	1	Epidermis
53	51	35	"	stom. & int	" "	"	1	Nothing
54	51	35	"	"	" "	"	1	Epidermis
55	51	35	"	stom. & int	" "	"	1	Epidermis? Copepoda 2
56	51	35	"	"	" "	"	1	Epidermis
57	51	35	"	97, stom. & int	" "	"	1	Epidermis, plant tissue
58	51	28	"	"	" "	"	1	Epidermis, Copepoda 1, Collembola 1
59	50	27	"	"	" "	"	1	Nothing

Table 1. Data for *Rana catesbeiana*---Continued

No.	Body	Tail	Mouth	Ali. Can.	Fore Legs	Lot	FOOD
60	53	25	"	105	"	"	1 Epidermis
61	50	25	"	90	"	"	1 Epidermis
62	53	20	"		"	"	1 Epidermis, Collembola 1, Capsidae 1, Diptera 1
63	51	20	"	93, stom. & int.	"	"	1 Nothing
64	50	20	"	88	"	"	1 Epidermis
65	55	20	"	"	"	"	1 Epidermis
66	51	19	"	91	"	"	1 Philoscia (Oniscidae) 1
67	53	18	"	"	"	"	1 Epidermis
68	55	17	"	"	"	"	1 Oribatella (Acarina) 1, plant tissue
69	52	15	"	90, stom. & int.	"	"	1 Epidermis, green algae
70	52	15	"	100	"	"	1 Epidermis
71	54	15	"	95	"	"	1 Staphylinidae 1, Formicidae 1
72	52	14	"	"	"	"	1 Epidermis
73	54	14	"	"	"	"	1 Nothing
74	52	12	"	stom. & int.	"	"	1 Epidermis
75	54	12	"	"	"	"	1 Epidermis, Curculionidae 1
76	51	10	"	93	"	"	1 Epidermis
77	52	9	"	85	"	"	1 Epidermis?
78	53	8	"	"	"	"	1 Lestes vigilax (Zygoptera) 1, seed
79	54	7	"	"	"	"	1 Staphylinidae 1, Formicidae 1
80	58	7	"	"	"	"	1 Diffugia 3, Hydrachna 1, Aphididae 1, Myrmicidae 1
81	53	5	"	115	"	"	1 Epidermis
82	53	5	"	"	"	"	1 Collembola 3, Rana tadpole 1
83	49	5	"	90	"	"	1 Epidermis, Oribatidae 1, Insecta 1, Aphididae 1
84	52	5	"	95	"	"	3 Epidermis, Spirogyra
85	52	4	"	95	"	"	1 Collembola 1, Coleoptera 2, Staphylinidae 1, Laccophilus 1, Dasyllidae 1 larva, Formicidae 1, egg 1, achene of Scirpus
86	57	4	"	"	"	"	1 Epidermis, unidentifiable material
87	53	4	"	"	"	"	1 Collembola 1, plant fiber
88	53	4	"	"	"	"	1 Epidermis, unidentifiable material
89	55	4	"	"	"	"	1 Nothing
90	52	3	"	90	"	"	1 Acarina several, Lestes nymph
91	52	3	"	"	"	"	1 Nothing identifiable
92	50	3	"	85	"	"	1 Collembola 1, Cercopidae 1
93	50	2	"	"	"	"	1 Acarina 1, Collembola 1, Cercopidae 1, Agromyzidae 1, Anthonomus (Curculionidae) 1, Aphodius 1, bits of Sphagnum
94	53	1	"	"	"	"	1 Coenagrionidae 1, Carabidae 1
95	55	0	"	145	"	"	3 Gerridae 1, Lepidoptera 1 larva, Cladophora, Spirogyra
96	53	0	"	"	"	"	1 Coenagrioninae 1, nymph
97	50	0	"	"	"	"	1 Copepoda 1, Agromyzidae 1, Elateridae
98	93	0	"	"	"	"	1 Elateridae 1, young Rana catesbeiana, grass seed
99	80	0	"	"	"	"	1 Clubionidae (Araneida) 2, Orihatidae 1, Collembola 3, Creniphilus 1, Coleoptera 1, Sphagnum, twig
100	56	0	"	"	"	"	1 Oribatidae many, Collembola many, Panorpidae, 1, Cercopidae 1, Agromyzidae 1, Coleoptera 1, Hydrophilidae 1 larva
101	63	0	"	"	"	"	1 Aphididae several, Agromyzidae 2
102	80	0	"	"	"	"	1 Nauplius many, Copepoda several, Collembola 1, Coenagrioninae 1, Coleoptera 1, Elateridae 1, Curculionidae 1, Hymenoptera 1, Aphididae 1, Bidens seed, Sphagnum leaves, plant fibers
103	73	0	"	"	"	"	1 Diffugia, Copepoda many, Acarina several, Coenagrioninae 1, Zygoptera nymph, Psocidae 1, Hemiptera 1, Coleoptera 1, Chrysomelidae 1, Carabidae, Curculionidae 1, Hydrophilidae 1, young Bufo, moss, thistle-down
104	80	0	"	"	"	"	1 Pentatomidae 1, Rhyncophora 2, Hydrophilidae 1, Apidae 1, much dirt, straw, moss-leaves, seeds, pieces of chitin

Rana clamitans Latreille. The Green-frog.

Total of 87 specimens. Lot 1, Crystal Beach, Canada, June, 1914; lot 2, Cascadilla Creek, Ithaca, July 22, 1907; lot 3, Bool's Backwater Ithaca, June 30, 1906; lot 4, Slaughter House Ponds, Ithaca, June 20, 1906; lot 5, same, June 10, 1907; lot 6, same, June 27, 1911; lot 7, same, June 30, 1911; lot 8, Dwyer's Pond, Ithaca, date not given; lot 9, Slaughter House Ponds, June 29, 1907; lot 10, same, June 29, 1907; lot 11, Cascadilla Ponds, Ithaca, July 7, 1916; lot 12, Dwyer's Pond, July 10, 1916; lot 13, Wood's Hole, Mass., July 16, 1909; lot 14, Dwyer's Pond, July 27, 1916; lot 15, Michigan Hollow Pond, Ithaca, Aug. 5, 1916; lot 16, Biological Station, Ithaca, June 30, 1911; lot 17, Bool's Backwater, Ithaca, Sept., 1912; lot 18, Ithaca, June 21, 1915. Lots 1-10, 16, 17, 18 collected by Dr. Wright; lot 13 by Dr. Wright and Dr. A. L. Leathers; lots 11 12, 14, 15 by Dr. Wright and myself.

Table 2. Data for *Rana clamitans*

No.	Body	Tail	Mouth	Ab. Can.	Forelegs	Lot	FOOD
1	34	63	tadpole	tadpole,	230	one	7
	32	60	tadpole	"	290	none	7
3	29	60	tadpole	stomach,	110	present	11
4	29	53	"	"	160	none	12
	30	53	"	tadpole,	440	none	12
	28	53	"	"	300	none	12
7	32	52	"	"	450	none	4
8	28	50	"	stomach,	250	"	9
	29	60	"	"	110	present	11
10	32	48	"	tadpole,	440	none	7
	31	55	changing	stomach,	120	present	16
	30	53	small	"	55	"	11
13	31	53	"	"	94	"	16
14	33	52	tadpole	tadpole,	91	"	12
15	27	51	small	"	90	"	12
16	31	50	"	stom & int	87	"	11
17	31	55	small	stomach,	120	"	16
18	31	47	"	stom & int	"	"	11
19	30	46	"	"	55	"	11
20	31	46	"	"	4	"	10
21	32	46	"	stomach,	50	"	10
22	28	46	"	"	185	"	12
1	28	46	"	stom & int	45	"	14
1	31	45	"	"	40	"	11
1	31	45	"	"	45	"	11
2	33	45	"	"	60	"	11
3	35	43	"	"	48	"	11
4	37	42	small	"	1	"	12
5	38	40	"	"	5	"	11
6	30	40	"	"	8	"	11
7	32	40	"	"	68	"	10
8	29	40	"	"	40	"	11
9	32	40	"	"	42	"	12
10	32	38	one-half	"	65	"	11
11	30	34	one fourth-stomach,	"	84	"	11
12	33	50	"	stom & int	100	"	16
13	33	32	"	stomach,	60	"	3

Table 2. Data for *Rana clamitans*---Continued

No.	Body	Tail	Month	Ali. Can.	Fore Legs	Lot	FOOD
37	26	30		stom. & int.	45	"	8 Epidermis, plant tissue
38	32	16		" "	44	"	9 Epidermis, Spirogyra, Zygnuma
39	35	14		" "	53	"	1 Epidermis ?
40	29	13		" "	45	"	9 Epidermis, plate of larval teeth
41	34	12		" "	72	"	4 Epidermis, small seed?
42	30	11		" "	45	"	11 Epidermis ?
43	31	10		" "	50	"	11 Epidermis
44	31	5		" "	46	"	5 Epidermis, sand
45	30	4		" "	50	"	11 Epidermis
46	35	2		" "	50	"	1 Agromyzidae 1, Coleoptera 1, Dytiscidae 1
47	36	2		" "	50	"	1 Epidermis, Agromyzidae 2, Leptidae 2, Formicidae 1
48	30	2		" "	58	"	5 Lycosidae 1, Lygaeidae 1, Ceratopogon larva, Curculionidae 2, Braconidae 1
49	32	2		" "	53	"	11 Tipulidae 2, Megilla maculata (Coccinellidae)
50	34	2	large	" "	50	"	16 Epidermis, Drassidae 1
51	31	2	"	" "	57	"	16 Insecta 1
52	36	1	"	" "	60	"	1 Zygoptera nymph, Leptidae 1, Formicidae 1
53	33	5	large	" "	60	"	17 Tipulidae 1
54	35	0	"	" "	58	"	1 Lycosidae and egg-sac, Scarabaeidae 1, Formicidae
55	34	0	"	" "	50	"	1 Epidermis, Coleoptera 4
56	31	0	"	" "	40	"	1 Pelecyptoda, Agromyzidae 1, Coleoptera 1, Formicidae 1
57	37	0	"	" "	85	"	2 Phalangidae 1, Jassidae 1, dirt and trash
58	35	0	"	" "	85	"	4 Coleoptera 1, Staphylinidae 1, Diptera 1
59	31	0	"	" "	80	"	7 Lymnaeidae 3, Nematoda 3, Araneida 1, Insecta 1, larva, Capsidae 1, Jassidae 1, Lepidoptera larva
60	32	0	"	" "	65	"	8 Nematoda 1, Panorpidae 1, Lepidoptera larva, Formicidae 2, mass of eggs, fruit of Juncus
61	32	0	"	" "	50	"	11 Epidermis ?, Dictynus (Araneida), Tipulidae 1
62	33	0	"	" "	45	"	11 Trematoda 1, Limnobatidae 1
63	41	0	"	" "	110	"	13 Libelluline nymph, Hydrophilidae 1, Psilopus (Dolichopodidae) 1, Plant material and sand
64	42	0	"	" "	85	"	13 Araneida 1, Anisoptera nymph, Curculionidae 1, Formicidae 1, Myrmicidae 1, Poneridae 1
65	41	0	"	" "	70	"	13 Diplopoda 1, Oniscidae 1, Araneida 1, Jassidae 1, Corixidae 1, Heteroneuridae 1, Diptera 1, Leptidae 1, Anthomyidae 1, Curculionidae 3, Ichneumonidae
66	39	0	"	" "	80	"	15 Ostracoda 1, Trematoda 4, Gastropoda 1, Jassidae, Coleoptera 1, Dytiscidae 1, Chrysomelidae 1, Rhyncites bicolor 1, Ephydriidae 1, Formicidae
67	38	0	large	" "	110	"	16 Lymnaea 2, Porcellio rathkei 6, Geometridae 1, larva, Carabidae 4
68	33	0	"	" "	81	"	16 Porcellio 1, grass, mud, plant fibers
69	35	0	"	" "	70	"	16 Coptocychla guttata 1, Diptera larva, Carabidae larva, bits of grass
70	40	0	"	" "	130	"	16 Porcellio 2, Theridiidae 1, Carabidae 4, Mud grass
71	31	0	large	" "	52	"	16 Epidermis, Capsidae 1, Empididae 1, Carabidae, Tenebrionidae 1
72	38	0	"	" "	100	"	16 Araneida 1, Insecta 1, Carabidae 1, larva and 1, adult, mud, plant fiber
73	33	0	"	" "	62	"	16 Hemiptera 1, Diptera 1, Carabidae 1
74	32	0	"	" "	64	"	16 Coleoptera 1, Carabidae 1, Curculionidae 1
75	35	0	"	" "	80	"	16 Epidermis Lumbricidae 1, Carabidae 1, Chrysomelidae
76	35	0	"	" "	72	"	16 Polygyra ? (Castropoda) 1
77	35	0	"	" "	94	"	16 Oniscidae 6, Lymnaea 2, Lithobius 1, Diptera 1, Coleoptera 1
78	38	0	"	" "	96	"	16 Oniscidae 4, Lumbricidae, Lymnaea 1, Argiopidae 1, Potamogeton leaf
79	36	0	"	" "	63	"	16 Argiopoidea 1, Diptera 1, Empididae 2, Coleoptera 1, Potamogeton leaf

Table 2. Data for *Rana clamitans*---Continued

No.	Body	Tail	Mouth	Ab. Can.	Fore Legs	Lot	FOOD
80	31	0	"	" "	86	"	16 Nothing identifiable
81	34	0	"	" "	75	"	16 Capsidæ 1, Jassidæ 1, Diptera 1, Empididæ 1, Carabidæ 3
82	26	0	"	" "	78	"	18 Phalangidæ 1, Philenus lineatus 1, Diptera adult and larva, Carabidæ 2, Formicidæ 1, Salix fruit; epidermis
83	34	0	"	" "	65	"	18 Nothing identifiable
84	36	0	"	" "	84	"	18 Phalangidæ 1, Carabidæ 1, Diptera 1, larva and 1 adult, Leptidæ 1
85	37	0	"	" "	72	"	28 Oniscidæ 18 nymphs, Hemiptera 1, Ceropidæ 1 nymph, Capsidæ 1, Diptera larva, Carabidæ 2, Rhyncophora 2
86	37	0	"	" "	100	"	18 Hemiptera 1, Tipulidæ 1, Carabidæ 1, Salix fruits 3, straw, unidentifiable material
87	37	0	"	" "	do.	"	18 Oniscidæ 1, Diplopoda 1, Dolichopodidæ 1, Coleoptera larva, Formicidæ 3 epidermis, Salix fruits 6

Rana sylvatica Le Conte. The Wood-frog.

Total of 100 specimens. Lot 1, Hamburg, N. Y., July 1, 1907; lot 2, Beehive Pond, Ithaca, July 22, 1907; lot 3, Cross-road Pond, Ithaca, July 4, 1907; lot 4, Beehive Pond, June 28, 1911; lot 5, Cross-road Pond, Ithaca, July 5, 1907; lot 6, Beehive Pond, July 31, 1907; lot 7, Beehive Pond, July 8, 1908. Lot 1 collected by Dr. A. A. Allen of Cornell University; lot 3 by Dr. Wright and Dr. H. D. Reed; the others by Dr. Wright.

Table 3. Data for *Rana sylvatica*

No.	Body	Tail	Mouth	Ab. Can.	Forelegs	Lot	FOOD
1	22	36	tadpole	tadpole,	200	none	4 Mud with Cymbella, Navicula, Nitzschia, Diatoma, Amphora, Fragillaria, Epithemia, Meridion, Microspora
2	16	28	"	"	65	"	3 Mud with Diptera, Eudorina, Oscillatoria
3	19	28	"	stomach,	60	present	4 Mud with Navicula, Pinnularia, Meridion, Stephanodiscus, Arcella, Epidermis?
4	15	25	"	tadpole,	130	none	2 Mud with Spirogyra, Oscillatoria, Closterium, Navicula
5	18	20	"	stomach,	105	present	4 Mud with Arcella, Diatoma, Navicula, Synedra, Scenedesmus
6	13	14	"	stom & int	28	none	1 Plant tissue, fibers; Navicula
7	12	12	"	stomach,	15	"	Nothing
8	18	1	small	"	37	present	4 Nothing identifiable
9	18	28	"	"	35	"	1 Nothing
10	18	27	"	stom & int.	28	"	4 Nothing
11	17	24	"	"	30	"	5 Nothing
12	16	23	"	"	25	"	3 Nothing
13	18	23	"	stomach,	53	"	4 Some mud with Navicula and Diatoma
14	15	22	"	stom & int	18	"	7 Nothing
15	16	21	"	"	24	"	3 Epidermis
16	17	20	"	"	24	"	3 Nothing
17	13	20	"	"	18	"	7 Nothing
18	15	20	"	tadpole,	14	"	7 Mud with Navicula and Fragillaria
19	14	19	"	"	14	"	7 Nothing
20	19	18	"	stom & int	30	"	4 Diatoma, Monocotila
21	14	18	changing	tadpole,	40	"	7 Mud with Gomphonema and Synedra
22	19	16	small	stom & int	28	"	4 Nothing
23	13	17	"	"	18	"	1 Nothing identifiable
24	12	13	"	stomach,	21	none	1 Plant tissue
25	13	13	"	tadpole	"	"	7 Mud with Diatoma, Navicula, Gomphonema, Fragillaria
26	12	12	large	stomach,	17	present	1 Nothing
27	20	11	small	"	31	"	5 Epidermis

Table 3. Data for *Rana sylvatica*---Continued

No.	Body	Tail	Mouth	Ali. Can.	Fore Legs	Lot	FOOD
28	18	10	one-half	stom. & int.	18	"	1 Nothing
29	13	10	small	" "	18	"	1 Epidermis
30	15	10	"	" "	21	"	7 Nothing
31	13	9	large	" "	15	"	1 Plant tissue and fibers
32	19	9	"	" "	15	"	4 Epidermis ?, Zygnuma, Mougeotia, Tri- bonema, Cymbella, Navicula, Fragil- laria
33	17	8	"	" "	15	"	3 Epidermis ?
34	18	8	small	" "	25	"	4 Epidermis ?
35	18	7	one-half	" "	20	"	5 Epidermis, Zygnuma
36	18	5	"	" "	16	"	5 Epidermis ?
37	18	5	large	" "	20	"	5 Epidermis ?
38	19	5	"	" "	21	"	4 Epidermis ?, threads of Mougeotia and Zygnuma
39	12	5	"	" "	13	"	1 Plant tissue
40	20	5	small	" "	26	"	4 Epidermis, Zygnuma, Mougeotia, Oscil- latoria
41	19	4	"	" "	22	"	4 Epidermis ?, Spirogyra, Mougeotia
42	17	4	large	" "	"	"	5 Nothing
43	18	4	"	" "	17	"	5 Epidermis ?
44	18	3	"	" "	14	"	5 Nothing
45	18	3	large	" "	16	"	5 Nothing
46	18	2	"	" "	20	"	5 Epidermis, Zygnuma
47	15	2	"	" "	18	"	7 Collembola
48	15	2	"	" "	15	"	2 Epidermis
49	18	2	"	" "	16	"	5 Epidermis
50	18	2	"	" "	25	"	3 Epidermis, Psocidae 1
51	17	2	"	" "	25	"	3 Epidermis ?
52	18	2	large	" "	22	"	5 Epidermis
53	18	2	"	" "	21	"	5 Epidermis ?
54	17	2	"	" "	17	"	5 Epidermis, Zygnuma
55	19	1	"	" "	20	"	5 Epidermis
56	17	1	"	" "	21	"	5 Epidermis, Psocidae 1
57	17	1	"	" "	23	"	5 Epidermis
58	17	1	"	" "	18	"	5 Nothing
59	17	1	"	" "	26	"	6 Planorbis 1, Collembola 1, Chrysomel- idae 1, Proctotrupidae
60	15	1	"	" "	23	"	6 Asellus 1, Chironomidae 1, Proctotru- pidae 1
61	17	1	large	" "	20	"	5 Epidermis, Diptera 1
62	17	1	"	" "	19	"	5 Mud with Spirogyra and Eudorina
63	18	1	"	" "	18	"	5 Eudorina, Navicula, Oscillatoria
64	13	1	"	" "	16	"	1 Acarina 1, Corrodentia 1, Diptera 1, Chironomidae 1 larva, Hydrophilidae
65	16	1	"	" "	20	"	3 Coleoptera larva
66	17	1	"	" "	20	"	3 Epidermis
67	19	1	"	" "	25	"	4 Epidermis
68	15	1	"	" "	19	"	2 Acarina 1, Diptera 1
69	17	1	"	" "	25	"	6 Psocidae 2, Cynipidae 1, Proctotrupidae 1
70	13	0	"	" "	19	"	1 Hydrachnidae 2, Hydrophilidae 1
71	14	0	"	" "	18	"	1 Ephrydidae 1, Chrysomelidae 1
72	13	0	"	" "	19	"	1 Aphididae 1, Curculionidae 1, Procto- trupidae 1
73	12	0	"	" "	16	"	1 Chironomidae larva, some unidentifiable material
74	14	0	"	" "	19	"	1 Diptera 1, Hydrophilidae larva
75	15	0	"	" "	20	"	2 Collembola 1, Corrodentia 1, plant tissue
76	15	0	"	" "	16	"	2 Collembola 2, Hydrophilidae larva, Cyni- pidae 1
77	15	0	"	" "	19	"	2 Ephrydidae 1, Cynipidae 1, unidentifiable material
78	17	0	"	" "	21	"	5 Aranea 1, Aphididae 1, Diptera 2, plant tissue
79	18	0	"	" "	24	"	5 Insecta larva, Lygeidae 1, unidentifiable material
80	17	0	"	" "	20	"	5 Green algae
81	17	0	"	" "	28	"	6 Planorbis 3, Oniscidal, Collembola 3, Heteroptera 1, Braconidae 1
82	16	0	"	" "	23	"	6 Collembola 7, Diptera 1, Proctotrupidae 1, Braconidae 1, 4 anthers
83	17	0	"	" "	27	"	6 Diptera 3, Carex seed
84	16	0	"	" "	27	"	6 Epidermis, Collembola 1, Hydrophilidae larva, sand, Proctotrupidae 2, anther 1

Table 3. Data for *Rana sylvatica*—Continued

N	Body	Tail	Mouth	Al. Can.	Fore Legs	Lot	FOOD
85	16	0		0	22	"	6 Insecta 1, Jassidae 1, Diptera 1, Chironomidae 1, Tipulidae 1, Hydrophilidae 1
86	17	0			27	"	6 Acarina 1, Chironomidae 4 larvae, Lepidoptera larva
87	15	0			1	"	6 Duffugia 1, Acarina 1, Collembola 2, Diptera 2 larvae, Phoridae 1, seed, stellate trichomes of plant
88	17	0			24	"	6 Jassidae nymphs
89	16	10			23	"	7 Collembola 3, Fulgoridae 1, Staphylinidae 1, Lepidoptera 2 larvae, Diptera 1
90	17	0		0	27	"	7 Curculionidae 1, Phoridae 1, Braconidae 1, Proctotrupidae 1
91	17	0		0	35	"	7 Lycosidae 1, Phoridae 1, Anthomyiidae 1, Staphylinidae, Proctotrupidae 1, Cynipidae 1, Chalcididae 1
92	16	0			22	"	7 Diptera 1, Chalcididae 1
93	17	0			28	"	7 Diptera 1, Phoridae 1, Chalcididae 1
94	17	0			28	"	7 Araneida 1, Collembola 5, Diptera 1, Coleoptera 1, Chalcididae 1
95	15	0		0	18	"	7 Collembola 4, Diptera 1
96	15	0		0	25	"	7 Collembola 2, Phoridae 1, Diptera 1, Ichneumonidae 1, bit of down feather
97	15	0			28	"	7 Linyphiidae 1, Fulgoridae 1, Diptera 1, Coleoptera 1, Hydrophilidae 1, Curculionidae 1, insect eggs
98	14	0			28	"	7 Linyphiidae 2, Psocidae 5 nymphs, Diptera 2, Proctotrupidae 2
99	15	0		0	23	"	7 Oribatida 1, Coleoptera larva, Proctotrupidae 1, one empty anther
100	13	0			23	"	7 Psocidae 3 nymphs, Lepidoptera larva, Diptera 1, Coleoptera 1, Staphylinidae 1

Rana palustris Le Conte. The Pickerel-frog.

Total of 100 specimens. Lot 1, Michigan Hollow Pond, Ithaca, Aug. 5, 1916; lot 2, Bool's Backwater, Ithaca, Sept. 1, 1912; lot 3, same, July 29, 1907; lot 4, Cross-roads Pond, Ithaca, Aug. 6, 1907; lot 5, Bool's Backwater, Aug. 6, 1907; lot 6, no date nor locality. Lot 1 collected by Dr. Wright and myself; lots 3, 4, 5 by Dr. Wright; lots 2 and 6 presumably by him.

Table 4. Data for *Rana palustris*

N	Body	Tail	Mouth	Al. Can.	Fore Legs	Lot	FOOD
1	35	48	tadpole	tadpole	200	none	1 Mud with Monocotia, Merismopedia, Microcystis, Scenedesmus, Navicula, Pinnularia, Diatoma, Eunotia, Nitzschia, Cosmarium, Closterium, Pandorina
2	38	47	changing	tadpole	168	"	2 Mud with Navicula, Diatoma, Synedra, Epithemia, Gomphonema, Oscillatoria, Monocotia, Spirogyra, Zygnema, Scenedesmus, Closterium
3	23	44	tadpole		100	"	1 Mud with Gomphonema, Navicula, Diatoma, Pinnularia, Scenedesmus, Closterium, Cosmarium, Merismopedia
4	31	33	"		400	"	1 Mud with Duffugia, Diatoma, Navicula, Synedra, Eunotia, Gomphonema, Nitzschia, Melosira, Scenedesmus, Epithemia, Spirogyra
5	31	60	changing		135	one	3 Mud with Navicula, Oedogonium, many Strongyloide, the latter probably parasites
6	23	40	small	tadpole	150	one	1 Mud with Merismopedia, Oscillatoria, Closterium, Scenedesmus, Cosmarium, Navicula, Protozoan parasite

Table 4. Data for *Rana palustris*---Continued

No.	Body	Tail	Mouth	Ali. Can.	Fore Legs	Lot	FOOD
7	24	40	small	stomach,	70	present	4 Nothing
8	27	44	"	"	65	"	1 Nothing
9	23	43	changing	"	64	"	1 Mud with Closterium, Paramoecium, Pleurococcus, plant tissue
10	25	42	small	"	55	"	1 Epidermis?
11	21	24	"	"	70	"	3 Little mud at end of ali. can.
12	24	41	"	"	54	"	1 Nothing
13	30	46	"	"	46	"	1 Epidermis?
14	25	46	"	"	45	"	1 Nothing
15	25	40	"	"	31	"	1 Nothing
16	26	40	"	"	32	"	4 Nothing
17	27	38	"	"	56	"	2 Nothing
18	26	39	"	"	43	"	4 Nothing
19	25	38	"	stom. & int.	38	"	1 Nothing
20	27	38	"	stomach,	36	"	4 Nothing
21	27	33	"	"	44	"	2 Nothing
22	26	33	"	"	46	"	2 Nothing
23	23	33	"	"	33	"	1 Nothing
24	27	33	"	"	27	"	4 Epidermis
25	22	33	"	"	28	"	5 Nothing
26	25	30	"	"	33	"	2 Nothing
27	25	29	"	"	30	"	2 Nothing
28	23	28	"	"	33	"	3 Nothing
29	26	28	two-thirds	"	28	"	1 Nothing
30	35	28	one-third	"	25	"	1 Nothing
31	25	27	one-half	"	31	"	2 Nothing
32	25	24	"	"	25	"	1 Epidermis
33	25	17	"	stom. & int.,	35	"	1 Epidermis
34	27	13	one-half	"	28	"	1 Epidermis
35	27	12	"	"	28	"	1 Epidermis, Zygnuma, Mougeotia
36	22	10	"	"	28	"	5 Epidermis
37	24	10	two-thirds	"	32	"	2 Epidermis, Spirogyra, Zygnuma, Vaucheria, Mougeotia, Navicula, Diatoma
38	21	10	"	"	34	"	5 Epidermis?
39	24	8	"	"	28	"	5 Epidermis
40	23	7	"	"	23	"	1 Epidermis
41	24	7	"	"	32	"	5 Nothing
42	25	9	large	"	24	"	5 Epidermis, Spirogyra, Oscillatoria, Diatoma, Synechra
43	27	6	"	"	28	"	5 Epidermis, egg of Daphnia, one of Simocephalus, bit of plant tissue
44	23	6	"	"	26	"	5 Epidermis
45	23	5	"	"	33	"	5 Epidermis
46	26	5	"	"	24	"	1 Epidermis
47	25	5	"	"	30	"	5 Epidermis
48	21	5	"	"	24	"	5 Epidermis
49	24	5	"	"	30	"	5 Epidermis
50	23	5	"	"	32	"	5 Epidermis
51	24	5	"	"	30	"	5 Epidermis, mud, Navicula, Eunotia, Gomphonema, Spirogyra
52	23	5	"	"	34	"	6 Epidermis, Empididae? 1
53	29	4	"	"	42	"	1 Epidermis
54	32	4	"	"	27	"	1 Epidermis
55	27	4	"	"	29	"	1 Epidermis
56	25	4	"	"	26	"	1 Epidermis, egg of Simocephalus, 7 eggs of Daphnia, several statoblasts
57	24	4	"	"	30	"	5 Collembola 1
58	25	4	"	"	27	"	5 Tipulidae 1, Achene of Eleocharis acicularis
59	27	4	"	"	40	"	1 Epidermis, Oribatella 1
60	25	3	"	"	31	"	1 Epidermis
61	26	3	"	"	28	"	1 Epidermis, plant fibers
62	26	3	"	"	28	"	1 Epidermis, Jassidae 1
63	25	3	"	"	28	"	1 Epidermis
64	25	2	"	"	35	"	5 Phoridae 1, Chironomidae pupa, Coleoptera larva, Staphylinidae 1, achene of Eleocharis acicularis
65	25	2	"	"	33	"	5 Lygaeidae 1, Attidae 1
66	23	2	"	"	30	"	1 Jassidae 1
67	26	2	"	"	28	"	1 Epidermis, Crustacea egg, Carex seed
68	23	2	"	"	30	"	5 Nothing
69	23	2	"	"	30	"	5 Epidermis
70	23	2	"	"	30	"	5 Epidermis, Phoridae 1
71	26	2	"	"	"	6	Epidermis, Lepidoptera larva, Diptera 2 larvæ, Drosophilidae 1, Carabidae 1

Table 4. Data for *Rana palustris*---Continued

	Body	Tail	Mouth	Alt. Can.	Fore Legs	Lot	FOOD
72	27	1	"	"	35	1	Epidermis, Hydrachnidæ 1, Jasside 1, Diptera 1, Coleoptera 1, few algal filaments
73	27	1	"	"	34	1	Epidermis, Staphylinidæ 1
74	25	1	"	"	35	1	Lygaeidæ 1, Nabidæ nymph, Ephychridæ ? 1
75	27	1	"	"	32	1	Epidermis with Mougeotia, Haltica ? 1
76	24	1	"	"	31	5	Epidermis, Proctotrupidæ 1
77	24	1	"	"	33	6	Epidermis, Drassidæ 2, Chalcididæ 1, Insecta 1
78	26	0	"	"	35	6	Diptera adult and larva, Pollenia 1, Rhyncophora 1
79	25	0	"	"	35	6	Phoridae 1, Coleoptera larva
80	26	0	"	"	26	6	Epidermis
81	28	0	"	"	34	6	Lepidoptera larva
82	25	0	"	"	35	6	Diptera 1, Drosophilidæ 1, Carabidæ 1
83	25	0	"	"	32	5	Planorbis 1, Heteroptera 1, Staphylinidæ 1
84	27	0	"	"	33	1	Epidermis, egg of Crustacea, Gamasidæ 1, Mougeotia
85	27	0	"	"	33	1	Tipulidæ 1, Dytiscidæ 1, plant tissue, Ichneumon pieces of chitin
86	27	0	"	"	31	1	Epidermis, Capsidæ 1
87	25	0	"	"	30	1	Crustacea egg, Physopoda 1, Collembola 1, Formicidæ
88	27	0	"	"	44	1	Lymnæa 1, Laccobius 1, sand
89	25	0	"	"	33	6	Aphididæ 1, Diptera 1, Rhyncophora 1, winged seed
90	26	0	"	"	36	6	Epidermis, Collembola 1, Chrysomelidæ larva, Braconidæ 1
91	28	0	"	"	48	6	Insecta larva, seed
92	27	0	"	"	50	6	Insecta larva, Hydrophilidæ 1
93	26	0	"	"	34	6	Epidermis, Heteroptera 1, Pollenia 1, Diptera 1
94	27	0	"	"	43	6	Epidermis, Lymnæa 1, Argiopoidæ 2, Jassidæ 1, Diptera 1, Drosophilidæ 1, Staphylinidæ 1
95	28	0	"	"	55	6	Lymnæa 1, Capsidæ 1, Psilopus 1, Laccobius 1
96	28	0	"	"	48	1	Daphnia eggs, Lianculus 1, Carabidæ 1, Halplus 1, Juncus ovari with Lepidop. larva, 2 Carex achenes
97	28	0	"	"	50	2	Insecta larva, Gryllus 1, Jassidæ 1, Cercopidæ 1, Diptera adult and larva, Tipulidæ 1, Acalyptera 1
98	28	0	"	"	40	6	Epidermis, Tipulidæ adult and larva, Haliplidæ 1, Proctotrupidæ 1, small leaf
99	28	0	"	"	42	1	Helochara (Jassidæ) 3, Tipulidæ 1, Coleoptera 1, Curculionidæ 1, Ephychridæ 1, Chalcididæ 1, Braconidæ 1
100	28	0	"	"	40	1	Argia nymph, Lygaeidæ 1, Reduviolus 1, Helochara 2, Sphaerophoria 1, Lianculus 1, Coleoptera larva, Philanthidæ 1, Braconidæ 1

Rana pipiens Schreber. The Meadow- or Leopard-frog.

Total of 100 specimens. Lot 1, Isoetes Ponds, Chicago Bog, McLean, N. Y., July 22, 1916; lot 2, Boul's Backwater, Ithaca, Sept. 1, 1912; lot 3, Taughannock Pond, Ithaca, July 29, 1908; lot 4, Boul's Backwater, Ithaca, Aug. 18, 1906; lot 5, Chicago Ponds, McLean, N. Y., July 30, 1910. Lot 1 collected by Dr. Wright and myself; lot 2, by Dr. Wright; lot 3, by Dr. A. A. Allen; lot 4, by Dr. Wright and Dr. G. H. Sabine; lot 5, by Dr. Wright and Dr. R. G. Gilmore.

Table 5. Data for *Rana pipiens*

No.	Body	Tail	Mouth	Ali. Can.	Forelegs	Lot	FOOD
1	29	44	tadpole	tadpole,	530	none	1 Mud with Navicula, Diatoma, Synedra, Spirogyra, Oedogonium, Ulothrix, Vaucheria, Anuraea, fibers, moss
2	29	37	"	"	405	"	1 Mud with Cladophora, Navicula, much moss
3	27	37	"	"	210	"	4 Mud with Gomphonema, Cymbella, Navicula, Cocconeis, Cyclotella, Diatoma, Synedra, Meridion, Spirogyra
4	27	36	"	"	360	"	1 Mud with Epithemia, Navicula, Acanthidium, Vaucheria, pieces of leaves, xylem spirals, broken tissue
5	28	48	changing	stomach,	150	present	4 Mud with Nitzschia, Synedra, Pinnularia, Gomphonema, Cocconeis, Navicula, Cymbella, Meridion, Diatoma, Cyclotella, Closterium, Spirogyra, Oscillatoria, Cypridopsis, plant tissue
6	28	42	"	"	118	"	1 Diatoma, Navicula, Scenedesmus, Mougeotia
7	28	50	"	"	113	"	4 Nothing
8	25	45	small	"	100	"	1 Mud with Navicula, Ulothrix, fibers
9	27	45	"	"	70	"	2 Nothing
10	29	44	"	"	80	"	4 Nothing
11	28	48	"	"	70	"	1 Nothing
12	28	43	"	stom. & int.,	80	"	4 Nothing
13	24	35	"	"	80	"	1 Mud with Closterium, Pleurococcus, filaments, plant tissue
14	27	38	"	"	42	"	4 Nothing
15	26	40	"	"	60	"	4 Nothing
16	27	40	"	"	58	"	1 Epidermis
17	25	37	"	"	64	"	1 Nothing
18	26	36	"	"	45	"	1 Nothing
19	27	35	one-half	"	37	"	1 Nothing
20	27	34	"	"	36	"	2 Nothing
21	25	34	"	"	36	"	2 Epidermis?, Oscillatoria, Zygnema, Spirogyra, Cladophora, Synedra, Desmidi-um, Gomphonema, Epithemia, Melosira, mandible of insect larva, shell of hivalve crustacea
22	27	33	"	"	50	"	1 Nothing
23	28	32	"	"	50	"	4 Epidermis
24	26	32	"	"	40	"	2 Epidermis, Zygnema, Synedra
25	27	30	"	"	30	"	1 Epidermis
26	22	30	"	"	42	"	1 Nothing
27	23	28	"	"	45	"	1 Nothing
28	27	28	"	"	42	"	1 Epidermis
29	28	24	large	"	40	"	2 Epidermis, Zygnema, Ulothrix, Mougeotia
30	28	22	"	"	51	"	4 Epidermis
31	27	20	"	"	38	"	1 Epidermis
32	28	20	"	"	35	"	1 Epidermis
33	23	20	"	"	28	"	1 Epidermis
34	22	18	"	"	32	"	1 Epidermis
35	23	15	"	"	30	"	1 Epidermis
36	26	15	"	"	40	"	1 Epidermis
37	21	15	"	"	28	"	1 Epidermis, small snail?
38	26	15	"	"	30	"	1 Epidermis
39	22	14	"	"	28	"	1 Nothing
40	28	13	"	"	35	"	1 Epidermis
41	25	12	"	"	33	"	1 Epidermis
42	27	12	"	"	42	"	1 Epidermis
43	23	12	"	"	26	"	1 Epidermis
44	20	12	"	"	31	"	1 Epidermis
45	25	11	"	"	33	"	1 Epidermis
46	22	11	"	"	32	"	1 Epidermis
47	23	10	"	"	30	"	1 Epidermis
48	28	10	"	"	37	"	2 Chlorops (Oscinidae) 1, Muscidae 1, Culicidae 1, Heteroptera nymph, Jassidae 1, Aphididae 2
49	25	10	"	"	34	"	1 Epidermis
50	23	9	"	"	29	"	1 Epidermis
51	24	9	"	"	32	"	1 Epidermis
52	27	9	"	"	30	"	1 Epidermis, Drosophilidae 1
53	22	9	"	"	31	"	1 Epidermis
54	25	9	"	"	30	"	1 Epidermis, egg of Daphnia
55	24	8	"	"	35	"	1 Epidermis

Table 5. Data for *Rana pipiens*---Continued

No.	Body	Tail	Mouth	Ant. Can.	Fore Legs	Foot	FOOD
60	24	8	"	"	33	"	Epidermis
61	24	8	"	"	46	"	Epidermis, Simuliidae 2
62	27	"	"	"	38	"	Epidermis
63	27	"	"	"	42	"	Epidermis
64	27	7	"	"	31	"	Epidermis
65	27	6	"	"	36	"	Epidermis
66	24	6	"	"	36	"	Epidermis, Dytiscidae 2 larvae
67	27	6	"	"	32	"	Epidermis, Dytiscidae larva
68	27	5	"	"	42	"	Epidermis, Oribatidae 3, Collembola 1
69	25	5	"	"	31	"	Epidermis, Oribatidae 1
70	28	5	"	"	45	"	Epidermis, Lymnaea palustris 1, Aphididae 1
71	28	5	"	"	38	"	Oribatidae 1, Collembola 1, Diptera 1, Drosophilidae 1
72	18	5	"	"	31	"	Jassidae 2 nymphs, Aphididae 2
73	28	5	"	"	47	"	Mycetophilidae 2, Phortica 1, Crenophilus 1
74	28	4	"	"	47	"	Epidermis, Thysanoptera 1, Collembola 1, Aphididae 1, Dolichopodidae 1, Simuliidae 2, Braconidae 1
75	29	4	"	"	44	"	Nothing
76	21	4	"	"	35	"	Epidermis
77	32	4	"	"	45	"	Braconidae 1
78	23	4	"	"	31	"	Epidermis, Staphylinidae 1, Collembola 1
79	27	3	"	"	50	"	Cymecia 3, Muscidae 1
80	30	3	"	"	46	"	Epidermis, Collembola 1, Lymnaea 1
81	27	2	"	"	45	"	Epidermis, Tipulidae 1, Dytiscidae 1
82	25	"	"	"	40	"	Oribatidae 3, Daphnia eggs, Thysanoptera 2, Collembola 3, Jassidae 1, Psyllidae 1, Formicidae 1
83	28	2	"	"	33	"	Epidermis, Vermes 1
84	25	0	"	"	60	"	Heteroptera 1, Homoptera 1, Capsidae 1, Muscidae 1, Coleoptera 4
85	25	0	"	"	57	"	Coleoptera adult and larva, Capsidae 1, Cerecidae 1
86	25	0	"	"	54	"	Heteroptera 1, Diptera 1, Coleoptera 2
87	24	0	"	"	58	"	Araneida 1, Capsulae 1, Jassidae 1, Muscidae 2, Coleoptera 2, Hymenoptera 1
88	25	0	"	"	58	"	Coleoptera 2, Carabidae 1, Formicidae 1
89	26	0	"	"	56	"	Diptera 1, Coleoptera 1, Cleridae 1, Hymenoptera 1
90	26	0	"	"	45	"	Collembola 1, Lampyridae 1, Staphylinidae 1, Hymenoptera
91	29	0	"	"	60	"	Diptera 1, Coleoptera 1, Chrysomelidae 1, Hymenoptera 1, Philanthidae 1
92	28	0	"	"	63	"	Doryphora 1, Cleridae 5, unidentified 1
93	27	0	"	"	65	"	Diptera adult and larva, Coleoptera larva, Dytiscidae 1, Rhynchoptera 2, Braconidae 1
94	29	0	"	"	61	"	Jassidae 1, Carabidae 1, Chrysomelidae 1, Staphylinidae
95	27	0	"	"	57	"	Diptera 1, Coleoptera 1, Muscidae 1
96	24	0	"	"	55	"	Oribatidae 1, Jassidae 1, Diptera adult and larva, Carabidae 2, Staphylinidae 1, Formicidae 1, Braconidae
97	23	0	"	"	46	"	Lymnaea 1, Mycetophilidae 3, Phoridae 2
98	23	0	"	"	53	"	Diptera 1, Coleoptera 2 adults and 1 larva, Chrysomelidae 2, Proctotrupidae 1
99	26	0	"	"	55	"	Epidermis, Lymnaea 2, Thysanoptera 3, Collembola 1, Capsulae 1, Diptera 1, Drosophilidae 1, Coleoptera 1, Hydrophilidae 2, Chrysomelidae 1
100	27	0	"	"	62	"	Epidermis, snail, Carabidae 1, Drosophilidae 1, Formicidae 1
101	28	0	"	"	37	"	Epidermis, Heteroptera 1, Diptera 1, Carabidae 1, Rhynchoptera 1
102	28	0	"	"	34	"	Epidermis, Psyllidae 2, Diptera 1, Coleoptera 1 plant-down
103	26	0	"	"	36	"	Braconidae 1
104	25	0	"	"	43	"	Psyllidae 1, Diptera 1, Carabidae 1, Braconidae 1, 4 pebbles

Hyla crucifer Wied. The Spring Peeper.

Total of 32 specimens. Lot 1, Slaughter House Ponds, Ithaca, June 28, 1911; lot 2, Cross-roads Pond, Ithaca, June 22, 1907; lot 3, Slaughter House Ponds, June 27, 1911; lot 4, Chicago Bog, McLean, N. Y., July 22, 1916; lot 5, pond on shore of Lake Ontario, North Fair Haven, New York, July 30, 1916. Lots 1, 2, 3, by Dr. Wright; lot 4, by Dr. Wright and myself; lot 5, by myself.

Table 6. Data for *Hyla crucifer*

No.	Body	Tail	Mouth	Ali. Can.	Forelegs	Lot	FOOD
1	11	18	tadpole	tadpole,	66 none	1	Mud with Epithemia, Meridion, Gomphonema, Diatoma, Eunotia, Navicula, Synedra, Zygema, Mougeotia, Ulothrix, Microspora, Crustacea eggs, plant tissue, Paramœcium
2	12	17	"	"	80 "	2	Mud with Zygema, Oscillatoria, Microspora, Mougeotia, Scenedesmus, Navicula
3	10	16	"	"	17 "	1	Nothing
4	11	16	changing	stomach,	10 present	2	Nothing
5	11	16	small	"	11 "	1	Nothing
6	10	14	changing	"	11 "	2	Nothing
7	11	13	"	"	12 "	2	Nothing
8	11	15	"	"	13 "	1	Nothing
9	10	14	"	"	13 "	1	Nothing
10	11	11	small	"	12 "	1	Epidermis
11	10	11	"	"	12 "	1	Nothing
12	13	10	"	"	11 "	1	Nothing
13	11	10	"	"	15 "	1	Nothing
14	11	9	"	"	11 "	1	Nothing
15	11	8	"	"	12 "	1	Nothing
16	11	7	"	stom. & int.,	12 "	1	Nothing
17	11	7	"	"	12 "	1	Epidermis ?
18	12	6	large	"	13 "	1	Nothing
19	11	6	"	"	11 "	1	Nothing
20	12	5	"	"	13 "	3	Nothing
21	11	5	"	"	12 "	1	Nothing
22	12	5	"	"	18 "	3	Epidermis
23	12	2	"	"	14 "	3	Diptera 1
24	14	0	"	"	24 "	4	Cercopidae 2, Chalcididae 1, Ichneumonidae 1
25	14	0	"	"	20 "	4	Hemiptera 1, Tipulidae 1
26	14	0	"	"	22 "	4	Diptera 2, Coleoptera 1, Ichneumonidae 1
27	14	0	"	"	23 "	4	Diptera 2, Coleoptera 1, Ichneumonidae 1
28	11	0	"	"	14 "	1	Epidermis
29	11	0	"	"	17 "	1	Diptera 1
30	16	0	"	"	20 "	5	Diptera 1, Capsidae 1, Phoridae 1
31	16	0	"	"	19 "	5	Diptera 2, Proctotrupidae 2
32	15	0	"	"	25 "	5	Insecta 2, Hymenoptera 1

Hyla versicolor Le Conte. The Common Tree-toad.

Total of 23 specimens. Lot 1, Ithaca, July 20, 1911; lot 2, Ithaca, July 22, 1908; lot 3, Lake Ontario, North Fair Haven; lot 4, Ithaca, July 22, 1907. Lots 1, 2, 4, by Dr. Wright; lot 3, by myself.

Table 7. Data for *Hyla versicolor*

No.	Body	Tail	Mouth	Ali. Can.	Forelegs	Lot	FOOD
1	20	42	tadpole	tadpole,	170 none	1	Mud with Pleurotenium, Cosmarium, Desmidiium, Pediastrum, Scenedesmus, Navicula, Pinnularia, Epithemia, Anahana

Table 7. Data for *Hyla versicolor*---Continued

N.	Body	Tail	Mouth	Alt. Can.	Fore Legs	Lot	FOOD
2	16	22	"	"	170	"	4 Mud with Navicula, Pinnularia, Syne- dra, Pediastrum, Scenedesmus, Cos- marium, Oscillatoria
3	20	20	"	"	130	"	1 Mud with Pleurotenium, Cosmarium, Desmidiium, Pediastrum, Navicula, Pinnularia, Anabena
4	15	22	changing	stomach,	30	present	2 Nothing
5	14	11	small	"	20	"	2 Nothing
6	18	5	large	"	20	"	3 Epidermis
7	19	2	"	st. m. & int.,	24	"	3 Nothing
8	20	2	"	"	20	"	3 Epidermis
9	20	4	"	"	20	"	3 Epidermis
10	21	0	"	"	21	"	3 Insecta 1, Diptera 1, Cleridae 1
11	20	0	"	"	28	"	3 Epidermis, Oribatida 1, Diptera 1, Formicidae 1
12	21	0	"	"	23	"	3 Oribatida 1, Diptera 1
13	22	0	"	"	28	"	3 Psyllidae 2, Trichoptera 1, Diptera 1, Coleoptera Hymenoptera 1
14	21	0	"	"	30	"	3 Insecta 2, larva 1, Nabidae 2, Diptera 1, Ichneumonidae 1
15	20	0	"	"	25	"	3 Tingitidae 2, Jassidae 1, Psyllidae 3, Dip- tera 1, Hymenoptera 1, Chalcididae 1
16	22	0	"	"	30	"	3 Insecta 3, Cleridae 1
17	21	0	"	"	42	"	3 Tingitidae 1, Hymenoptera 1, Apidae 1, Myrmecidae
18	21	0	"	"	40	"	3 Tingitidae 17, Psyllidae 1, Coleoptera 1, Hymenoptera 1, plant down
19	20	0	"	"	23	"	1 Epidermis ?
20	20	0	"	"	23	"	1 Epidermis
21	20	0	"	"	25	"	1 Epidermis
22	20	0	"	"	18	"	1 Epidermis
23	19	0	"	"	19	"	1 Epidermis

Bufo americanus Holbrook. The Common Toad.

Total of 40 specimens. Lot 1, Dr. Wright and Dr. Reed, Cross-roads Ponds, Ithaca, July 4, 1907; lot 2, Dr. Wright, Bool's Backwater, Ithaca, June 29, 1911; lot 3, same, July 4, 1907.

Table 8. Data for *Bufo americanus*

N.	Body	Tail	Mouth	Alt. Can.	Forelegs	Lot	FOOD
1	11	12	tadpole	tadpole,	110	none	1 Mud with Zygnema, Oscillatoria, Navicula, Pandorina, eggs of Crustacea
2	11	12	"	"	80	"	1 Mud with Oscillatoria, Microspora, Pandorina, Navicula, Pinnularia, eggs of Crustacea
3	10	11	changing	stomach,	30	present	1 Mud
4	9	12	"	"	30	none	1 Mud with Pandorina, Navicula
5	9	12	tadpole	"	25	"	2 Mud with Navicula and plant tissue
6	9	12	changing	"	17	present	1 Nothing
7	9	12	"	"	16	"	2 Mud with Navicula and plant tissue
8	10	13	small	"	15	"	1 Nothing
9	10	11	two thirds	"	16	"	1 Epidermis ?
10	10	11	small	"	14	"	1 Nothing
11	9	10	one-half	stom. & int.,	20	"	1 Nothing
12	10	9	"	"	15	"	1 Nothing
13	9	9	"	"	13	"	1 Nothing
14	10	9	"	"	13	"	1 Nothing
15	9	7	"	"	14	"	1 Nothing
16	10	7	"	"	12	"	1 Nothing
17	10	7	"	"	10	"	1 Nothing
18	9	7	"	"	10	"	1 Nothing
19	8	6	two-thirds	"	12	"	2 Epidermis ?
20	9	5	"	"	12	"	3 Mud nothing identifiable
21	8	3	"	"	10	"	3 Mud
22	11	2	"	"	13	"	3 Nothing identifiable
23	11	2	large	"	11	"	3 Nothing identifiable

Table 8. Data for *Bufo americanus*---Continued

No.	Body	Tail	Mouth	Ali. Can.	Fore Legs	Lot	FOOD
24	10	2	"	" "	12	"	3 Nothing identifiable
25	9	2	"	" "	12	"	3 Epidermis
26	10	1	"	" "	13	"	3 Epidermis
27	10	1	"	" "	11	"	3 Nothing identifiable
28	10	5	"	" "	13	"	3 Epidermis ?
29	11	5	"	" "	13	"	3 Mud with Navicula, masses of Pleurococcus
30	9	0	"	" "	13	"	2 Physopoda 1, Insecta 1
31	11	5	"	" "	13	"	3 Pulmonata 1
32	10	0	"	" "	16	"	3 Epidermis, iptera larva
33	11	0	"	" "	13	"	3 Collembola 2
34	11	0	"	" "	12	"	3 Nothing identifiable
35	11	0	"	" "	12	"	3 Nothing
36	10	"	"	" "	10	"	3 Epidermis
37	10	0	"	" "	10	"	3 Epidermis, Diptera 1
38	10	0	"	" "	11	"	3 Nothing
39	9	0	"	" "	10	"	3 Nothing
40	10	0	"	" "	10	"	3 Epidermis

Comparison of Tadpoles of the Various Species.

In the eight species used the tadpoles agree in being for the most part herbivorous. The small mouth is provided with horny jaws and is used largely in nibbling off Algae, bits of moss, and other plants, and in gathering up masses of ooze and mud with the many diatoms and desmids to be found in such situations, and the occasional Protozoa of the *Diffugia* and *Arcella* types.

Very often one sees statements such as made by Miss Dickerson that tadpoles, especially of some species, are very "fond of any animal food available. Thus these tadpoles act as scavengers and dispose of dead fish or dead tadpoles even, that would otherwise become a menace to the living creatures of the pond." These statements might indeed be made by almost anyone who has observed tadpoles to any extent. I remember when a boy of reading that a good way of cleaning a skeleton of a small animal like a mouse was to place it in a pond containing many tadpoles and it would soon be nicely freed from the flesh. Experiment showed this to be more or less true; but although I have studied many tadpoles in the series of forms now being discussed, and although these come from many different ponds, the fact that in no case was such animal matter found, leads me to believe that it is not so important a source of food to the tadpole as is commonly believed.

Since all the tadpoles of the various species are aquatic and therefore in rather uniform conditions, one would not expect their food to vary as much as does that of the transformed individuals. The alimentary canal is invariably very long, in keeping with the herbivorous habits; but almost entirely undifferentiated, no stomach nor large intestine being evident. As long as the tadpole mouth is present the alimentary canal is almost always filled with ooze and silt, a great part of which is inorganic. Since the size of the mouth varies considerably with the species, one would expect it to allow of more variation in food-habit than does any other one factor. I was particularly interested, therefore, to see what the largest animal form taken would be and in which species it would be found. Unfortunately I did not have a very good series of specimens with the tadpole mouth in the large bull-frog and green-frog, but those examined showed almost no variation from the smaller species. One green-frog did have a small crustacean (*Ceriodaphnia*?), a meadow-frog contained a rotifer (Anuræa), another had a crustacean (*Cypridopsis*), and a peeper was found with

many winter eggs of Crustacea. Aside from the few cases of *Euglena*, *Paramarcium*, *Diffugia* and *Ircella* met with, almost all of the remaining food was plant. No attempt was made to make any quantitative observations on the plant materials found. In number of individuals and actual amount of substance the diatoms were very important; many desmids, some filamentous algae, and quite large amounts of wood-fibers and tracheids, bits of leaves and other broken down plant tissues were found. This is another bit of evidence in the rather vast amount which has now accumulated to show the great importance of the diatoms in aquatic biology and ecology. Table 9 shows in a relative way the frequency of occurrence of the various forms of food.

TABLE 9
The Frequency With Which the Various Species of Tadpoles Contained
the Various Food-forms.

Specimens opened	Bull- frog 3	Green frog 10	Wood- frog 7	Pick- erel frog 4	Meadow frog 4	Peeper 3	Tree- toad 3	Toad 2
DIATOMS								
Epithemia	1		1	2	1	1	1	
Navicula	2	6	5	4	5	2	3	2
Pinnularia	2	1	1	2			3	1
Diatoma	2	4	2	4	2	1		
Synedra	1	4	1	2	2	1	1	
Nitzschia	1	4	1	2				
Cymbella	2	1	1	1		1		
Meridion	2		2		1	1		
Eunotia		3		2		1		
Gomphonema		3	1	3	1	1		
Miscellaneous	1	2	2		2			
FILAMENTOUS ALGAE								
Zygnema		4		1		2		1
Flothrix	1				1			
Spirogyra	1	4	1	2	2			
Cladophora		1			1			
Mougeotia		2		2		2		1
Miscellaneous		1	1		3			
BLUE GREEN ALGAE								
Oscillatoria	2	3	2	1		1	1	2
Anabaena		1					2	
OTHER ALGAE								
Closterium		1	1	3	1			3
Cosmarium				2				3
Pediastrum								3
Desmidiun								2
Pleurotenium								2
Scenedesmus				4		1		2
Ceconais			1		1			
Merismopedia				2				
EL AGELLATA		2	2	1				2
PROTOZOA		1	1			1		
ROTIFERA					1			
CRUSTACEA	1				1			
EGGS OF CRUSTACEA		1				1		2

The figures given in this table indicate the number of stomachs in which the various forms occurred, as no attempt was made to keep a count of the number of times any one form was found in a given stomach.

Comparison of Young Transformed Individuals of the Various Species.

Just a glance given at the data of the transformed individuals of the eight species as presented in the preceding pages, will show in a general way that their food consists largely of insects with some spiders, mites, and other forms, largely as

has been reported for the adults by previous workers. I think it is worth while, however, to go into more detail and to see, for example, whether the young frogs and toads change at once to the more or less terrestrial habits of the adults or whether they feed largely on the aquatic forms at first. Let us see, too, whether they are limited very much by their size as to their range of food, and whether they begin their predaceous habits at once or still feed on the diatoms and algae on which they grew.

Perhaps a table comparing the different species will show most readily what we desire. In Table 10 the animal forms contained in the stomachs examined have been listed, the attempt being made to separate those which are without question aquatic from those probably not taken in water. The Collembola, young Anura, and insect eggs might have been taken on water or not and are classed as doubtful. It is possible, of course, that any of the winged insects might have fallen into water and have been seized as they were struggling or floating on the water, but this could scarcely have been true of many. Anyone who has watched transforming Anura knows that they hop briskly about in the neighborhood of the pond and have every opportunity to catch their prey in the air, from the surface of the mud, or from plants.

TABLE 10
Relative Numbers of Aquatic and Non-aquatic Animal Forms Found in
Transformed Individuals.

	Bull- frog	Green frog	Pick- erel frog	Meadow frog	Wood frog	Peeper	Tree toad	Toad
Protozoa	4				1			
Water Snails		8	4	8	4			
Crustacea and eggs.....	16	1	15	4	1			
Water Mites	1		1		2			
Odonata Nymphs	3	3	1					
Aquatic Hemiptera		2			1			
Chironomid Larvæ		1	1		6			
Aquatic Coleoptera	6	3	5	6	7			
Rana Tadpole	1							
TOTAL AQUATIC FORMS.....	31	18	27	18	22			
Collembola	19		3	10	37			2
Eggs	2	1						
Young Anura	2							
Doubtful Forms	23	1	3	10	38			2
Vermes		10		1				
Land Snails		2		1				1
Land Crustacea	1	39			1			
Myriapods		3						
Spiders	1	18	5	1	6			
Land Mites	17		2	9	5		2	
*Land Insects	2	4	4	1	4	2	7	1
Adult Odonata	5							
Thrips			1					
Crickets			1					
Land Hemiptera	10	16	21	27	9	4	30	
Scorpion Flies	1							
Psocids	1				12			
Lepidopterous Larvæ	1	2	3		4			
Diptera	6	36	28	35	32	10	6	1
Dipterous Larvæ			5	2	2			1
Coleoptera	21	48	13	41	12	2	4	
Coleopterous Larvæ			4	3	3			
Hymenoptera	6	19	9	18	24	7	17	
TOTAL NON-AQUATIC FORMS.....	71	200	96	139	113	25	66	5
TOTAL ANIMAL FORMS.....	125	219	126	167	173	25	66	7
Per Cent Aquatic Forms.....	25%	8%	21%	11%	13%	0%	0%	0%
Per Cent Doubtful Forms.....	18%	1½%	2%	6%	22%	0%	0%	29%
Per Cent Land Forms.....	57%	91%	76%	83%	65%	100%	100%	71%
Number of Stomachs.....	29	40	41	40	40	9	8	5

*Not further identifiable.

It is unfortunate that no more transformed individuals were available for the toad, the per cents recorded for it are probably not worth a great deal; however, the fact that no aquatic forms were found even in the five individuals studied is suggestive and made understandable by the fact that young toads soon leave the ponds by hundreds and at transformation time can be seen traveling toward the higher ground in all directions. The absence of aquatic or even doubtful forms in both species of *Hyla* can probably be substantiated by the examination of larger numbers; for young tree-frogs and peepers climb on plants above the ponds in which their larval life was spent and, sitting on the leaves and branches of *Iris*, of shrubbery, or whatever is available, are ready to catch insects that crawl over the plants or come flying to them.

It is noticeable, too, that the distribution of the forms eaten through many families and orders is not nearly so great for these smaller species as for the species of *Rana*. Dr. Wright¹ has shown that for the Ithacan Anura the average lengths at transformation are as follows:

<i>Bufo americanus</i>	9.6 mm.
<i>Hyla versicolor</i>	16.0 "
<i>Hyla crucifer</i>	11.0 "
<i>Rana pipiens</i>	24.0 "
<i>Rana palustris</i>	24.0 "
<i>Rana sylvatica</i>	16.0 "
<i>Rana clamitans</i>	32.0 "
<i>Rana catesbeiana</i>	53.0 "

The smaller size of some species naturally limits their food somewhat. The habit in both species of *Hyla* of sitting on plants, and their failure to hop about over the ground as do some of the other forms may also have much to do with the explanation of their eating fewer kinds of insects and other invertebrates such as spiders and sow-bugs.

In the genus *Rana* a general tendency toward the habits of the adults is to be observed; although the green-frog is a marked exception. One would expect young bull-frogs to eat a rather large per cent of aquatic forms and the rather low per cents given in Table 2 for the wood-frog and meadow-frog are not surprising. But the remarkably low per cent for the green-frog was hardly to be looked for. In this connection a comparison with the data given by Surface² for the adult forms may be of interest. His report lists the stomach-contents of 29 bull-frogs, of 107 green-frogs, 28 wood-frogs, 88 pickerel-frogs, 51 meadow-frogs, 17 peepers, 22 tree-toads, and 52 toads. By making a rough estimate of the forms which he lists I find that the comparison with the newly transformed is as follows:

¹Wright, A. H., 1914. Life-histories of the Anura of Ithaca, New York. Carnegie Institution of Washington.

²Surface, H. A., 1913. Economic features of Amphibians of Pennsylvania. Zoological Bull. Pa., Dept. of Agriculture, 3, 67-152.

TABLE 11

Percentage of Aquatic Forms Found in the Food of Adults as Compared with Newly Transformed.

	Bull-frog		Green-frog		Wood-frog		Pickerel-frog		Meadow-frog		Peeper		Tree toad		Toad	
Aquatic	25	32	8	6	13	2	21	4	11	7	0	0	0	0	0	0
Doubtful	18	5	1/2	4	22	0	2	1	6	0	0	0	0	0	29	1
Non-aquatic	57	63	91	90	65	98	76	95	83	93	100	100	100	100	71	99

In this table the figures express per cents, the one given first is for the young, the second being for adult. It will be at once apparent that the bull-frog is by far the most aquatic in feeding-habit, that the green-frog, although a form remaining close to the water, lives very largely on non-aquatic insects, that the peeper, tree-toad, and toad apparently eat practically no aquatic forms from the time that they transform, and that the wood-frog, pickerel-frog, and meadow-frog leave the water more gradually and always do have a small percentage of their food aquatic, although not so much of it is so in the adults as in the young. Of all these species the green-frog is perhaps the most surprising. Drake's¹⁰ results for the meadow-frog, based on the most exhaustive study yet made and showing a total of 931 animals found in 209 stomachs, give about five per cent as being unquestionably aquatic, so that his work agrees very well with the results given above.

Economic Bearing.

The economic application of a piece of work of this sort should be two-fold. As new information is obtained regarding the food-habits of frogs, especially at transformation, their life-history and propagation can be better understood. If frogs are unable to eat at transformation, a fact which I think I have quite thoroughly established, it is useless to feed them at that time. The second point of application that comes to mind is that a study of the food of the newly transformed may show something as to the usefulness of the species in destroying harmful insects, sow-bugs, slugs, and other forms. My data are hardly full enough nor important enough to go into this in detail, but a more extended investigation of the food of the adults is worth while from this standpoint. The results of other workers, such as Kirkland, Surface, and Drake, do show that a great many harmful forms are destroyed. For more detail their writings should be consulted.

Conclusions and Summary.

Eight species of *Anura* were studied during their transformation to learn something of their food-habits as larvæ, as transforming individuals, and as young frogs or toads. The species studied were as follows:

<i>Rana catesbeiana</i> Shaw.	The Bull-frog.
<i>Rana clamitans</i> Latreille.	The Green-frog.
<i>Rana sylvatica</i> Le Conte.	The Wood-frog.
<i>Rana palustris</i> Le Conte.	The Pickerel-frog.
<i>Rana pipiens</i> Schreber.	The Leopard- or Meadow-frog.
<i>Hyla crucifer</i> Wied.	The Peeper.
<i>Hyla versicolor</i> Le Conte.	The Tree-toad.
<i>Bufo americanus</i> Holbrook.	The Common Toad.

¹⁰Drake, C. J., 1914. The food of *Rana pipiens* Schreber. Ohio Naturalist, 14:257-269.

In each species studied the same general tendencies are evident: (1) The larval alimentary canal is very long, but slightly differentiated in its various portions, and filled with ooze and mud scraped up from objects in the pond and containing many forms of diatoms, blue-green and green algæ of filamentous and non-filamentous types, small pieces of plant tissue, and bits of fiber and other slowly decaying material to be found in ooze. Very few tadpoles were found with any animal food, the exceptions having a few small Crustacea, Protozoa and Rotifera.

(2) After both pairs of legs are evident and the horny plates of the tadpole mouth are shed, the tail is found to be gradually absorbed and the alimentary canal decreases to about one-tenth of its larval length at the same time that it widens anteriorly to form the stomach and posteriorly to form the large intestine. During this transformation period the mouth increases to about six or seven times its former size and there is practically no feeding done. The epidermis is apparently shed rather frequently as the tail is being absorbed; for its presence in the alimentary canal during the final stages of transformation is so frequent as to be quite universal in the larger species and occurs in all those studied.

(3) After these changes have been just about completed the young frog or toad begins life as a carnivor, apparently taking anything movable yet small enough for it to handle. Occasional bits of plant-down and small feathers testify to the attractiveness of a moving object. Almost all groups of invertebrates and some vertebrates are represented in the diet, the largest per cent being insects, crustaceans, spiders, sow-bugs, and snails. Some individuals do contain pieces of plant tissue, sand, mud, and other inactive objects, but these seem to be accidental, often occurring where ground beetles or similar forms have been eaten.

(4) The newly transformed individuals show a decided tendency toward the habits of the adults; the toad, tree-toad, and peeper eating almost nothing of an aquatic nature; the meadow-frog, pickerel-frog, and wood-frog eating some aquatic forms, a few per cent more than do the adults of their species; of the other two species, both of which are considered quite aquatic in habit, the green-frog has about nine-tenths of its food non-aquatic and the bull-frog about three-fourths non-aquatic.

By way of summary, then, the tadpoles of the species of *Anura* studied for this paper are largely herbivorous, the transforming individuals do almost no feeding, and the young frogs or toads are mostly carnivorous. These changes in habit are made possible by great changes in the alimentary canal and mouth.

The Central Nervous System of Three Bivalves

WILLIAM A. HILTON

Lima Deliscens.

The central nervous system forms a rather compact mass of nervous tissue, with certain special local thickenings where nerve cells are abundant. As in *Pecten*, as described by Drew, the visceral ganglion is the largest, but it is not so widely separated from the other ganglia as in *Pecten*. Neither is it so complicated in structure.

There are, on each side, three main branches from the visceral ganglion, the most caudal goes over the adductor muscle to the mantle. The next, the smallest main branch, goes to the gills, while the last branch, the largest, is chiefly a mantle branch, which divides after leaving the ganglion.

The cerebro-pleural ganglia are connected medio-caudally by a looped commissure, the other large medial branch on each side runs to the rather large pedal ganglion, while near it is the small otocystic branch, much as in *Pecten*. The large, more cephalic branch runs towards the mouth region and gives off a number of branches, about seven.

The pedal ganglion is made up of two nearly distinct parts and from each of these lateral parts a branch runs into the foot.

The visceral ganglion is more complex than the others in structure, but there are only a few distinct fiber tracts.

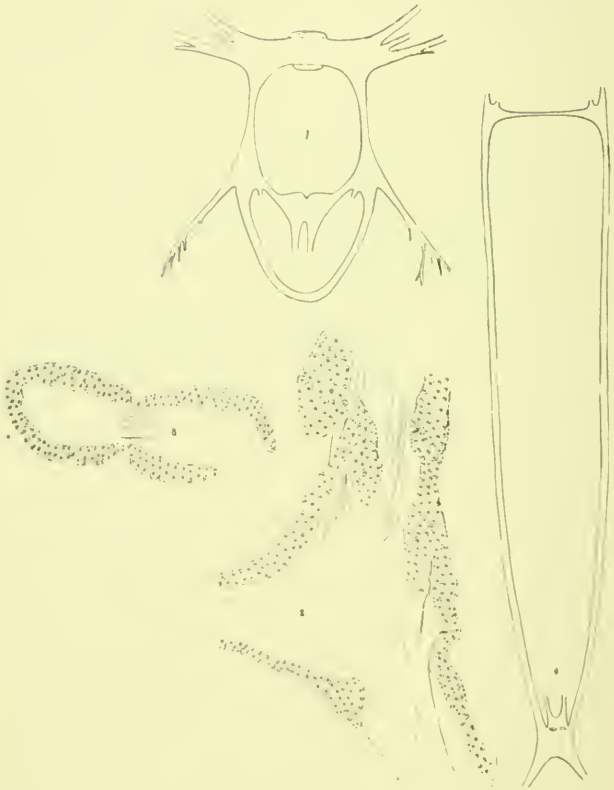
In all the ganglia, the cells are large or ganglionic and small or ordinary nerve cells.

Sunset Clam, *Psammobia californica*

The cerebral ganglia are of fair size and not widely separated. There is a cephalic branch supplying the mouth region and palps and a more ventral branch also on each side, supplies neighboring parts. The commissure between the two ganglia is rather narrow considering the size of these centers.

The Pedal ganglion is small and gives little indication of being divided into two parts. The two connectives come to it and two rather large branches leave.

The visceral ganglion is large and especially well developed. This is because of the large siphons and their necessary abundant nerve supply. The siphons are capable of being extended some distance from the shell. The ganglion is complexly lobed on superficial view. There are on each half at least six little lobes which represent to some degree groups of nerve cells. On each side in addition to the large connective branch there are branches as follows: (1) a large branch to the gills, (2) a large trunk which divides again into mantle branches. One of its branches going to the dorsal siphon, (3) a small dorsal branch, (4) a small ventral branch, (5) another large mantle branch which sends some strands to the ventral siphon, (6) another large mantle branch, (7) a small branch to the posterior adductor muscle.



- Fig. 1 Central ganglia of Lima X9.
Fig. 2. Section of Cerebral ganglion X70.
Fig. 3. Section of Pedal ganglion X70.
Fig. 4. Chief ganglia of Piddock X9.

Sections were made of the ganglia. The cerebral ganglia were found to be more complex than those of some other bivalves. This was shown in the differences in cell groups and greater complexity of the central fiber masses. The individual cells differ greatly in size, but they average somewhat larger than in some other bivalve forms studied.

The pedal ganglion, although not so complex, also shows differences between cells. There are large multipolar cells and among these are small ones of various sizes. The processes of the larger cells may be traced into the fibrous mass for some distance.

The visceral ganglion is composed of two large lateral parts closely fused. There are numerous commissural bands binding the two sides, but the chief fusion is by more or less individual fibers. Cells inclose the whole ganglion and as in the other centers they are of large and small size. The cell areas of the larger cells are mostly localized on the dorsal and upper surfaces, but the lower end of the ganglion has some large cells. The large cells are especially found in the neighborhood of the larger branches, those branches supplying the mantle and siphons and it seems that some of the larger cells are concerned with supplying these characteristic parts.

The California Piddock, *Parapholas californica* Conr.

The ganglia were dissected in medium sized individuals. The cerebral ganglia are about as in other bivalves. The ganglia are quite widely separated. Besides the commissures connecting them and connectives to lower ganglia there are several branches to the mouth region from the upper and lateral sides.

The visceral ganglion forms a larger mass than any other of the ganglia. There is very little indication of right and left halves. Closely joined to it is the small pedal ganglion.

Microscopic examination of serial sections bring out further details.

The cerebral ganglion is simple in structure. There are a large number of cells in proportion to the fibres in the center of the ganglia. As in many other molluscs, there are many small cells and a few much larger ones, but these last are not abundant. In the large cells it is not difficult to determine fine fibrils and strands from the smaller cells near by. There is also a very complex mingling of strands from the central fibrous mass. Some of the fibers are small, some are larger. The appearance of these larger cells is much as described by Apathy. The cells in the ganglion are chiefly multipolar.

The visceral ganglion is the largest and most complicated. Caudally it sends two thick nerves backwards. These are its chief branches for a long distance; they do not branch. The two sides of the ganglion are joined by many cross fibers and there are a few bundles in distinct commissures. Most of the cells are small, but there are a few of the larger type. The cells form a rather uniform sheath all about the ganglion, but here and there we find special cell areas. The fibers are much less evenly disposed and present a very complex mat in every part.

The large cells in some cases have a symmetrical distribution. There are certain individual lateral cells of this sort, also some dorso-central ones which seem to occupy

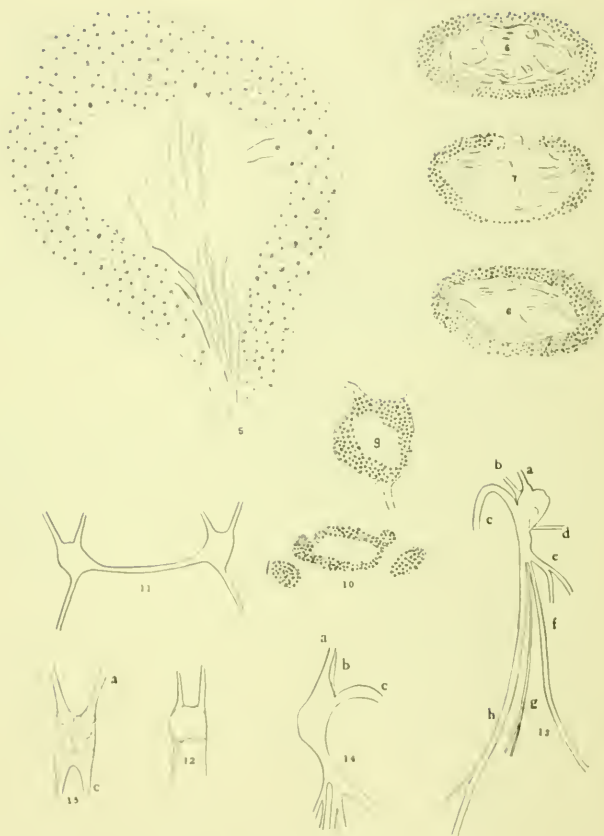


Fig. 11. Cerebral ganglia. X9. Sunset clam.

Fig. 12. Pedal ganglion. X9. Sunset clam.

Fig. 13. Visceral ganglion from the side. (a) Connective branch, (b) dorsal branch, (c) gill branch, (d) branch to posterior adductor muscle, (e) mantle branch, (f) mantle and ventral siphon branch, (g) small mantle branch ?, (h) mantle and dorsal siphon branch. Sunset clam.

Figs. 14 and 15. Other views of the visceral ganglion, lettering as in Fig. 3. X9.

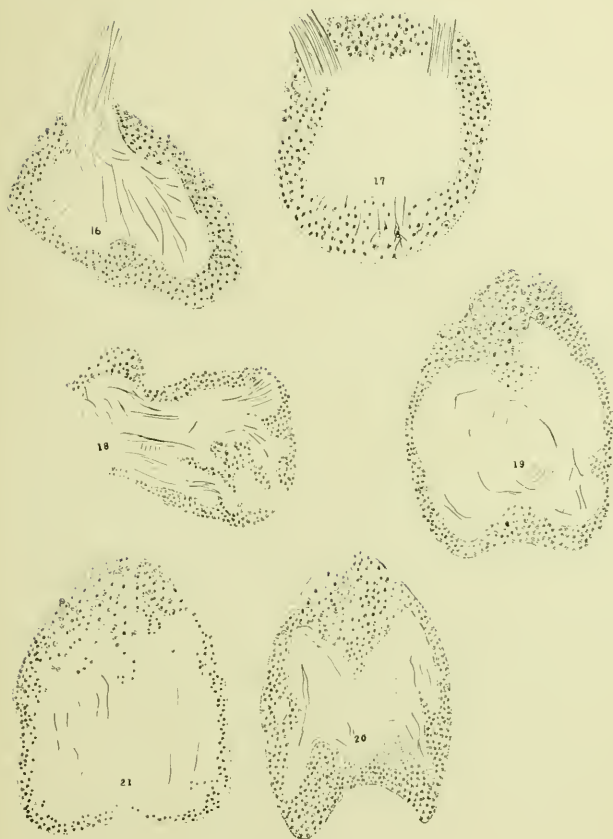


Fig. 16. Cerebral ganglion, section. The commissure shows. X70. Sunset clam.

Fig. 17. Longitudinal section of a pedal ganglion. X70. Sunset clam.

Figs. 18, 19, 20, 21. Various sections of visceral ganglion. The dorsal side is up. X70. Sunset clam.

characteristic positions. Also on the dorsal side there are two peculiar fiber masses in symmetrical positions.

The pedal ganglion is small and just in front of the visceral. It is almost a part of the visceral and closely applied to it. It has two chief nerves on the cephalic side. Its central fibrous mass is slight.

Explanation of Figures.

Fig. 4. Chief ganglia of Piddock. The cerebral ganglia are above, the visceral mass with the small pedal ganglion attached below. X9.

Fig. 5. One cerebral ganglion with part of the connective. X350.

Fig. 6. One cerebral ganglion, a branch above, the connective to the left, the commissure branch to the right. X70.

Figs. 7, 8 and 9. Sections through three levels of the visceral ganglion. The dorsal side is up. X70.

Fig. 10. Section through the pedal ganglion with the two connectives as isolated pieces each side. The dorsal side is up. X70.

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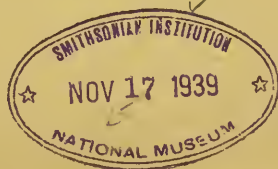
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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor
Claremont, California, U. S. A.

A List and Some Notes on the Lizards and Snakes Represented in the Pomona College Museum

RAYMOND B. COWLES

The purpose of this article is to give a general idea as to the distribution of snakes and lizards from the desert regions of Southern California, with a few observations on their habits. It is also an enumeration of the snakes and lizards which may be met with in the region about Claremont.

The list has been compiled from specimens in the Pomona College Museum only, and the writer is well aware that not all the specimens from the Claremont and desert regions are represented. No effort is made to give the limits of the range of the specimens nor to give any conclusions as final. In those cases where a list is given of the places from which specimens were taken, it is merely to show that the range is at least of that extent.

Testudo agassizi (Cooper).

One of these desert tortoise was taken at Ludlow, California, towards the last of April, 1920. It was found out in the open at the base of an alluvial fan, and made no effort to escape capture. It is being kept alive with a view to study its habits so far as possible under artificial conditions.

Dipsosaurus dorsalis (Baird and Girard).

Taken from fifteen miles east of Blythe Junction, April 2, 1920, in the sand hills. A second specimen was taken 45 miles west of Blythe, in a sand wash, on April 4, 1920.

The main habitat of this lizard seems to be the sand hills or sandy country, and it takes refuge in the holes of rats when menaced.

During August of 1919 they were seen in pairs and seemed to be breeding. Observations seemed to show that a given pair occupied the same territory and rarely traveled far from it. They were seen most on the hottest days, feeding on the leaves of some of the low desert shrubs. Upon being frightened they would drop from the branches and run rapidly, with the entire body raised from the ground, to the nearest burrow, where they would remain for half an hour or more before reappearing. On cloudy days, even though the temperature remained above 100° F. they were seldom seen and appeared to be very sluggish, sometimes allowing one to approach to within a few feet of them before running.

Their food seemed to be almost exclusively plants, and they preferred the leaves of an alfalfa plant which happened to be growing near their chosen range. During an entire summer, June 25 until September 25, they were seen eating insects only once. The specimen eating the insect escaped and it is not know what insect it might be, though from a distance it appeared to be one of the Acrididae.

Uma notata (Baird).

Only one specimen of this beautiful lizard is found in the museum, and it was taken in the sand hills 15 miles east of Blythe Junction, April 2, 1920. The lizard is very shy, running rapidly to the shelter of a burrow in the sand, at the least threat of danger. (This seems to be between *U. notata* and *U. scoparia*.)

Calisaurus ventralis ventralis (Hallowell).

This lizard appears to be one of the most numerous and widely distributed of the Colorado and Mojave deserts, having been found in almost every type of country with the exception of the rocky hills and mountains, from Victorville to Needles and south to the Mexican Border in Imperial Valley. In the Providence Mountains they were found at an altitude of over a thousand feet.

In the Imperial Valley they were found to burrow, or push down into the sand at the approach of night. Here they remained until sunrise of the next day. At the approach of danger they jump from the sand with such suddenness as to give the impression of a small explosion.

The distribution as given above is not intended as a limit to their range but merely a note on their presence in those places.

Crotaphytus collaris baileyi (Stejneger).

This lizard is represented by three specimens in the college collection. One taken from near the Bonanza King Mine, Providence Mountains, March 31, 1920; another from the N. E. spur of the Turtle Mountains, and a second and smaller one from the same place, April 1, 1920.

These lizards were found on the rocky hill-sides and were very active and rather shy. Their strong jaws and great speed fit them for the predaceous life which they lead. In the largest specimen was found an eight inch *Cnemidophorus tigris tigris*, partially digested.

Crotaphytus wislizeni (Baird and Girard).

Two specimens were taken at the grass fields between Blythe and Mecca, on April 2, 1920.

These specimens were found skulking under the branches of the creosote bushes. They are very rapid runners, and are predaceous. Their coloring blends admirably into the mottled shade where they lie in wait for their prey. A ten-inch *Cnemidophorus tigris tigris* was taken from an eleven inch specimen. Their biting ability was well proved upon the collector who picked up one of the specimens which had been only wounded. One bite tore through the skin of the first finger, causing a decided flow of blood.

Sauromalus ater (Dumeril).

One specimen taken in the lava rocks east of Ludlow, March 30, 1920. Two specimens taken among the rocks in the N. E. spur of the Turtle Mountains.

These lizards, which are not fast runners, are usually found near some crevice in the rocks in which they take refuge upon the approach of danger.

The two specimens taken in the Turtle Mountains, April 1, 1920, were found as a pair, and when first seen appeared to be in copula. This gives some suggestion as to the time of breeding.

Uta Stansburiana elegans (Yarrow).

Several specimens were taken during the first week in April, and they seem to be fairly common throughout a large part of the Mojave and Colorado deserts, in California at least.

Sceloporus magister (Hallowell).

One specimen taken 35 miles east of Mecca, California, April 2, 1920. Other specimens taken during July and August, east of Holtville, California. These lizards seem to prefer the brushy country or the neighborhood of trees, into which they climb when frightened. The specimen taken east of Mecca was found on the ground beneath a cactus.

Phrynosoma platyrhinos (Girard).

Representatives from five miles west of Amboy and Needles, California. Without an exception they were found on the dry gravelly washes or in the sand not far from washes.

Xantusia vigilis (Baird).

Three specimens from east of Victorville, and one from the Providence Mountains, near Bonanza King Mine, March 30, 1920. These specimens were all found beneath the bark of prostrate yuccas.

Cnemidophorus tigris tigris (Baird and Girard).

These lizards appear to be one of the most common found on the Colorado and Mojave deserts in California. Their range is extremely varied, specimens being taken from, and between, Victorville, Needles, Blythe, the Mexican border in Imperial Valley, and Palm Canyon. These localities are not given as the limits of the range but places within the range from which we have specimens. Specimens were taken in the Salton Sink 265 feet below sea level, and from the Providence Mountains at an approximate altitude of 2,800 feet above sea level.

Sonora occipitalis (Hallowell).

One specimen taken at the grass-fields, between Blythe and Mecca, California. When taken it was traveling out in the open and in the heat of the noon sun, April 3, 1920. It was found on a gravel wash and when approached it struck in all directions, though apparently it did not open its mouth upon striking the hand. It appeared to be blinded by the sun and unable to tell from which direction it was menaced.

Bascanion flagellum frenatum.

Two specimens, both taken near Mecca, Imperial Valley, April 4, 1920. Both these specimens were somewhat lighter than specimens taken from the region around Claremont, California.

One of these snakes was obtained under rather unusual circumstances, which incidentally involved the collecting of a *Cnemidophorus tigris tigris*. The lizard was shot but not killed by the collector, and while watching for an opportunity to kill the lizard without the use of a second shot, the snake was seen gliding in the same direction as the lizard, and suddenly attacked and seized it, when both were added to the collection.

Crotalus mitchelli (Cope).

This specimen was collected by Dr. Hilton and Dr. Munz of Pomona College, at Forest Home, San Bernardino Mountains, June 7, 1919.

Crotalus cerastes (Hallowell).

The specimen taken at Needles, California, April 1, 1920. These snakes seem to be almost entirely restricted to the sandy areas of the desert, rarely wandering from them, and then only for a short distance, its mode of locomotion admirably fits it for the type of country which it inhabits. The ordinary snake finds difficulty in rapid motion over the loose and shifting sand, since part of the tractive power comes from a bracing of each loop of the body against that part of the ground which is posterior to the loop, and through the movement of the central portion of the body against the surface of the ground. It can readily be seen that a shifting and loose surface would seriously hinder the progress of the ordinary snake. The "Side-winder," *Crotalus cerastes*, instead of progressing as do ordinary snakes, longitudinally, progresses laterally, leaving separate tracks, each paralleling the other, and angling in the direction in which the snake is moving. Each track is approximately the length of the snake making it, and is wavy, that is, a series of "S" shaped loops. The tracks give no sign of any part of the body moving from one mark to the other, which gives the impression that the snake jumps the 3 to 6 inch interval between the tracks. Such is not the case, however. When the snake is moving, the body is kept partially looped and the advance seems to be through the advancing of the head and tail, while the rest of the body is rested on the intervening loop, supporting the rest of the body, the weight then seems to be shifted to the head and tail and the rest of the body advanced, the whole progression being a series of graceful and continuous movements. This *seems* to be the mode of progression.

Crotalus atrox (Baird and Girard).

Taken at Mecca, California, April 4, 1920. Found in the arrow weed where it seemed to be fairly common.

In addition to the above list of specimens from the desert region there remain that from the vicinity of Claremont, California, which is as follows: *Uta stansburiana hesperis*, Richardson; *Sceloporus occidentalis bi-seriatus*, Hallowell; *Phrynosoma blainvillii blainvillii*, Gray; *Gerrhonotus scincicauda zeebii*, Baird; *Anniella pulchra pulchra*, Gray; *Anniella pulchra nigra*, Fisher (doubtful location. Specimen not labeled. Another from Laguna Beach August 1, 1920); *Cnemidophorus tigris stejnegeri*, Van Denburgh; *Plestiodon skiltonianus*, Baird and Girard; *Lichanura roseofusca*, Cope (two taken from vicinity of Claremont and one from east of Victorville by W. M. Pierce); *Thamnophis ordinoides hamondii*, Kennicott; *Diadophis amabilis*, Baird and Girard; *Lampropeltis pyromelana multincta*, Yarrow; *Lampropeltis boylii*, Baird and Girard; *Rhinocheilus lecontei*, Baird and Girard; *Hypsiglena ochrorhynchus*, Cope; *Salvadora hexalepis*, Cope (taken in Imperial Valley 10 miles east of Holtville); *Coluber constrictor vetustus*, Baird and Girard; *Coluber flagellum trenatus*, Stejneger; *Coluber lateralis*, Hallowell; *Pituophis catenifer catenifer*, Blainville; *Crotalus oreganus*, Holbrook.

The Central Nervous System of an Unknown Species of Marine Leach

WILLIAM A. HILTON

The little animals from which this study was made were obtained during the summer of 1920 at Laguna Beach. Two times when a number of *Mysis* shrimps were brought in with towings these worms were found attached by the posterior sucker to the side of the crustacean. At first it was not clear to which group of animals these small creatures belonged. It was not until a number of the specimens had been cut in series that their nature was learned. Externally they seemed unsegmented, although the body had many circular rings when contracted by reagents, but these rings were evidently not marks of segmentation. Internally at first there also seemed to be little trace of metamerism, but when the nervous system was examined a clearly defined chain of ganglia was evident.

The mouth is at the base of the large anterior sucker, and it is back of this that the ganglia may be seen. The chief ganglion is the suboesophageal composed of about four parts fused and closely applied to the next ganglion below. The brain or supraoesophageal ganglion is unimportant; in fact, it is the smallest of all. There are sixteen simple ganglia forming the ventral chain back of the suboesophageal and the seventeenth ganglion or last of the chain. The last center, or the seventeenth, is made up of at least three simple ganglia fused and is the second most important center. It supplies the structures of the large posterior sucker.

Some of the points of special interest in the nervous system of this creature are:

1. Lack of true metamerism except in the nervous system.
2. The large number of simple clearly defined nerve centers. About four centers are represented in the suboesophageal, sixteen separate ganglia and at least three separate centers for the last ganglion. In all then there are at last twenty-three centers in the nervous system.
3. The small size of the supraoesophageal ganglion or brain.
4. The large size of the suboesophageal ganglion and the last ganglion.
5. No special sense organs were located.

The specimens were from 4-8 mm. in length and, although small, were sexually mature. The identity of the species will be considered at another time.

(Contribution from the Zoological Laboratory of Pomona College.)



EXPLANATION OF FIGURES

Below, the general position of the ganglia is shown. On the left above is an enlarged longitudinal section of the upper ganglia and just below it a cross-section through the brain and subesophageal with the œsophagus in the space between. The two upper central figures are longitudinal and cross-sections of about the tenth ganglion. The last figure to the left is a longitudinal section of the last ganglion. The dorsal side is up in all the figures. The sections are all enlarged 170 times, the figure of the whole animal is enlarged 20 times.

Central Nervous System of a Centipede

ARTHUR S. CAMPBELL

The central nervous system of *S. Polymorpha* Woods, is especially studied in the present paper.

Hymonds (1898) considers the development giving especial note to the homologies of this system. Newport (1843) gives some notes in regard to the brain. Saint-Remy (1890) gives considerable detail especially in regard to the finer structure of the brain of *S. Morsitans* L. Case (1920) has shown something of the behavior of *S. Polymorpha* and indirectly the arrangement of nerve tracts.

Ordinary dissections and the occasional use of a binocular microscope proved the most useful.

Successful stains were Heidenheim's and Delafield's Haematoxylins. HgCl_2 or AgNO_3 seemed the best fixers. Tracheae were studied without reagents immediately after exposure.

In *S. Polymorpha* the supraoesophageal ganglion or brain comprises three paired, fused divisions or lobes. Large branches extend from the antennal lobes into the antennae. The ocular lobe fuses with this and is distinctly larger and less markedly bilobate. This lobe sends out nerves to the ocelli. The labro-frontal division is underneath the ocular lobe and entirely fused with it. It innervates the labrum.

The supraoesophageal ganglion in *S. Polymorpha* is large. It is anteriorly connected with the brain by two circumoral connectives. Ten principal, paired nerves are connected with this ganglion. The anterior pair extend into the mandibles. The second pair supplies the first maxillae, the third runs to the second maxillae. The fourth pair innervates the maxillipeds. The fifth pair supplies the prehensorial feet.

The remaining somites are supplied by simple, similar ganglia, equally spaced but well separated by connectives. The third and fourth ganglia are almost fused, due to the foreshortened segments in which they are located. There is no histological difference between them and other abdominal ganglia. One ganglion only is present in each somite. Altogether in *S. Polymorpha* there are twenty-four ganglia.

Each abdominal ganglion gives off eight nerves. There is no ventral nerve. The first pair of branches supplies the tergal muscles, the second the walking legs, the third the sternal muscles and the fourth supplies the spiracles and tracheae.

The two caudal ganglia present special interest. Four principal branches run from the first of these. The first supplies the tergal muscles, the second the sternal muscles while the fourth supplies the anal legs. Additionally, two preanal connectives join with a small ganglion about half the normal size of the others. Four nerves extend from this last small ganglion into the sphincter and other anal muscles.

In general the superficial tracheal distribution is rather definite and much resembles that of the insects. The brain is rather poorly supplied by but two main tracheae on either side which break up into a number of tracheoles which run into the antennae and optic lobes. In contrast to this, the suboesophageal ganglion is supplied dorsally by three tracheae on each side.

The abdominal ganglia are each supplied by two ventral tracheae. The dorsal tracheae send vessels throughout the length of the branches on the dorsum of the ganglion. Each ganglion is well supplied by numerous small tracheoles.

The two caudal ganglia present some differences in the distribution of tracheal elements. The dorsal surfaces of the twenty-third and twenty-fourth ganglia is supplied by six tracheae. Ventrally there is one principal branch supplying both by numerous tracheoles.

Histologically the brain and other ganglia resemble much those of the more generalized insects. I have found little difference in my specimens and those figured by Saint-Remy (1890) of *S. Morsitans*. The cellular masses of all my preparations seem much less than those figured by Saint-Remy. The fibrous area of the brain contains some indication of lobular masses. There are at least two sizes of cells noticeable.

In the abdominal ganglia the fibrous mass occupies rather more than half the bulk. The cellular area, composed of several sizes of cells, is closely crowded.

The caudal ganglia contain less bulk of the fibrous mass and a large area of cells. The cells here seem to be all of approximately the same size and type.

In all preparations, the nuclei appear large, the nucleoli show prominently. Pigroid substances was noticed in a few of the larger, better stained cells, especially in the brain. Fibrils were seen to enter into certain cells, and touch the nuclei.

CONCLUSIONS

1. The central nervous system of *S. Polymorpha* is composed of twenty-four generalized ganglia. The brain is less complex than that of the insects.

2. Of the three primitive elements of the brain two only are externally apparent.

3. Tracheae supplying the central nervous system are definitely arranged.

4. The functional cells of the central nervous system are of several sizes, the fibrous mass makes up the greater bulk of the ganglion. The cellular area is external and relatively less abundant.

5. Nuclei are large, nucleoli are well marked. Fibrils appear to come into contact with nuclei.

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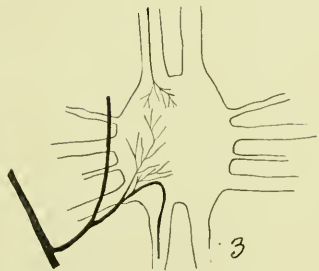


Fig. 1. Brain and subesophageal ganglion; tracheæ black. X6.
 Fig. 2. Twenty-third and fourth ganglion. X5.
 Fig. 3. Abdominal ganglion. X5.

Microscopic Studies of the Water of the Claremont-Laguna Region

GENEVEIVE CORWIN

The climatic conditions in Southern California where these studies were made, are unusual in that the rainy season occurs during the winter and early spring and there is practically no rainfall for the rest of the year. About 10 to 15 inches is the average yearly amount. With this small amount of precipitation, most of the streams dry up completely and the permanent pools diminish in size. This fact has a profound effect upon the life contained in the water. Just how this effect works out has not been determined. Some forms are able to dry up and still retain life, while others are killed by lack of moisture. Almost all the studies recorded in this paper were made on permanent pools and streams.

Studies of the microscopic life of the Claremont-Laguna region were made in the early spring and summer, those of the Claremont region in February, March and April; and of the Laguna region during the last half of June and the month of July of the previous year.

Considering the two places as a whole, in general there were more green algae than blue-green; more algae than Protozoa, the amoeboid Protozoa being fewest in number; the flagellate a little more numerous and the ciliate most frequent, both in species and individuals. The rotifers were rather rare, but were quite varied in form, from the simply constructed, active *Colurus* to the beautifully ciliated fixed *Floscularia*. The *Gastrotricha* were very rare.

The chief difference between the Claremont and the Laguna regions is the abundance of aquatic life. This might be caused by the fact that most of the pools studied around the Laguna were close to the shore and the water may have been brackish. As a rule they were more stagnant than the Claremont water, with the exception of the Laguna Lakes. Perhaps the seasonal change may have had something to do with this difference. The Claremont studies were made over a period of time twice as long as the other and much earlier in the season. However this may be, in almost every group there were more species in the Claremont region than the Laguna and in all other cases there were at least as many, with the one exception of the one desmid found in Claremont and not in Laguna. To summarize the comparison: There were twice as many species of algae in the Claremont region as the Laguna; the same number of blue-green for both localities but four times as many green in Claremont. The diatoms were quite numerous and varied in form in both places but there were only half as many species in Laguna. As mentioned before, one desmid was found in Claremont and none in Laguna.

The Protozoa were quite abundant in both regions, there being three times as many in Claremont as in Laguna. In Claremont the amoeboid were twice as numerous as at Laguna. There was a larger proportion of beautiful complicated forms in the Claremont region. There were three species of *Stentor* in Claremont and only two in Laguna. The restless little *Euplates*, the graceful *Spirostomum*, the beautiful *Stylonychia* are illustrations of the variety of ciliates in Claremont.

There were one-half more rotifers in Claremont than Laguna. However, Laguna had in comparative abundance the very interesting form, *Rotifer neptunis*. This form is quite long and slender when extended, with two rosettes of cilia and a quite unmistakable Neptune's trident at the end of the tail. It is very collapsable, telescoping down to one-third of its extended length. This was peculiar to the smaller Laguna Lake.

Claremont showed several specimens of *Brachionus*. I am not certain of the species but the name must stand for want of a better one. It was a large form with two magnificent wheels of cilia and two short slender arms, each bearing a tuft of cilia. When the animal drew in the wheels of cilia at least one of these arms remained exposed. It was rather sedentary, fastening its two small toes to a piece of algae and bending its flexible, stout body in different directions to search for food.

Only one *Gastrotricha* was found in the Claremont region while this same genus (*Chaetonotus*) was found in two different places and more than one individual was seen.

Microscopic Crustacea were rather rare, only one (*Cyclops*) being found in the Sulphur Spring at Laguna. Three other kinds were found in the Claremont region, two in the South Hills, the other at Puddingstone Canyon and in the Puente Hills.

One water mite was found in Claremont in a temporary pool and in no other place.

The comparison between the temporary and permanent pools is not adequate on account of the scarcity of data. In a general way, there is a smaller variety and number of forms in the temporary than in the permanent pools. Streams and permanent pools are similar in the amount of life they contain.

Preliminary List of Microscopic Life in Fresh Water Pools Around Laguna Beach

- I. Algae
 - A. Blue-green
 1. Oscillatoria: found in
 - Algae Pool
 - Smallest Laguna Lake
 - Largest Laguna Lake
 2. Spirulina
 - Smallest Laguna Lake
 - Largest Laguna Lake
 - Algae Pool
 - Laguna Canyon Pool
 3. Nostoc
 - Smallest Laguna Pool
 - Algae Pool
 - Laguna Canyon Pool
 4. Nodularia
 - Laguna Slough
 5. Phormidium
 - Smallest Laguna Lake
 - B. Green
 1. Cladophora
 - Salt Spring
 2. Synedra
 - Laguna Canyon
 - Smallest Laguna Lake
 3. Ankistrodesmus
 - Algae Pool
 - Laguna Slough
 4. Spirogyra
 - Laguna Canyon Pool
 - Laguna Slough
 - Smaller Laguna Lake
 5. Scenedesmus
 - Largest Laguna Lake
 6. Navicula
 - Laguna Canyon
 - Algae Pool
 - Salt Spring
 - Sulphur Spring
 - Smallest L. Lake
 7. Amphora
 - Algae Pool
 8. Cymbella
 - Sulphur Spring
 - Smallest Laguna Lake
 - Largest Laguna Lake
 9. Pinnularia
 - Smallest Laguna Lake
 - Salt Spring
 10. Gomphonema
 - Smallest Laguna Lake
 11. Closterium
 - Smallest Laguna Lake
 12. Pleurosigma
 - Smallest Laguna Lake
 13. Epithemia
 - Smallest Laguna Lake
- III. Protozoa
 - A. Amoeboid
 1. Amoeba
 - Algae Pool
 2. Nuclearia
 - Salt Spring
 - B. Flagellate
 1. Euglena spirogyra
 - Smallest Laguna Lake
 2. Euglena sp.
 - Laguna Canyon
 - Laguna Slough
 3. Phacus longicaudis
 - Smallest Laguna Lake
 - Laguna Canyon
 - C. Ciliate
 1. Gonium
 - Smallest Laguna Lake
 1. Flexiphyllum
 - Smallest Laguna Lake
 3. Condyllostoma
 - Smallest Laguna Lake
 - Largest Laguna Lake

- Laguna Canyon
- 4. Paramoecium
 - Laguna Slough
 - Algae Pool
 - Sulphur Spring
 - Salt Spring
- 5. Lacrymaria
 - Laguna Canyon
- 6. Stentor (fixed)
 - Laguna Canyon Stentor
 - (moving) Smaller L.
 - Lake
- 7. Vorticella
 - Smallest Laguna Lake
 - Laguna Slough
 - Algae Pool
 - Laguna Canyon
- 8. Volvox
 - Largest Laguna Lake
- IV. Flat Worms
 - 1. Jensenia
 - Laguna Canyon
- V. Round Worms
 - Smallest Laguna Lake
 - Laguna Canyon
 - Algae Pool
- VI. Rotatoria
 - A. Rotifer neptunis
 - Smallest Laguna Lake
 - B. Rotifer citrinus
 - Sulphur Spring
 - Salt Spring
 - Laguna Canyon
 - C. Diplois
 - Smallest Laguna Lake
 - D. Colurus grillator
 - Smallest Laguna Lake
 - Salt Spring
 - Laguna Canyon
 - Algae Pool
 - E. Notius quadricornus
 - Smallest Laguna Lake
 - F. Philodina roseola
 - Laguna Canyon
- VII. Gastrotricha
 - A. Chaetonotus
 - Laguna Canyon
 - Smallest Laguna Lake
- VIII. Copepoda
 - A. Cyclops
 - Sulphur Spring

Preliminary List of Microscopic Life in Fresh Water Around Claremont

The numbers after the genera refer to the stations where the collections were made.

I. Algae

A. Blue-green

2. *Oscillatoria* 3, 6, 7, 9.
3. *Nostoc* 1, 9.
4. *Merismopedia* 2, 3, 4.
5. *Spirulina* 2.
6. *Mastigonema* 3.

B. Green

1. *Vaucheria* 11.
2. *Cladophora* 4, 8, 11, 13, 14, 15.
3. *Clamydomonas* 2, 3, 7, 8, 13, 14, 15.
4. *Gonium* 13, 14, 15.
5. *Spirogyra* 1, 3, 5, 7, 8, 9, 14.
6. *Ulothrix* 13.
7. *Mougeotia* 13.
8. *Myrrodiclyon* 2.
9. *Pediastrum* 2, 12.
10. *Scenedesmus* 2.
11. *Chlorosphaera* 3.
12. *Chaetophora* 8, 9, 14.
13. *Zygnema* 7, 8.
14. *Chlorogonium* 7.
15. *Myxonema* 7.

C. Diatoms

1. *Navicula* 1, 2, 3, 4, 7, 8, 9, 11, 12, 13, 14, 15.
2. *Epithemia* 8, 9, 12, 14, 15.
3. *Synedra* 1, 2, 3, 4, 5, 7, 8, 9, 13, 14, 15.
4. *Cocconeis* 1, 3, 5, 8, 9, 13, 14, 15.
5. *Stirella* 7, 8, 12, 13, 14, 15.
6. *Gomphonema* 1, 2, 3, 4, 5, 7, 8, 13, 15.
7. *Amphora* 2, 7, 8, 13, 15.
8. *Nitzschia* 1, 4, 7.
9. *Rhoicosphenia* 3, 4, 7.
10. *Tabellaria* 7.
11. *Cymbella* 2, 13, 15.

12. *Selenastrum* 2.

13. *Cyclotella* 2, 4, 13.

14. *Pinnularia* 2.

15. *Encyonema* 3, 8, 13, 14.

16. *Denticula* 3, 5, 8, 11, 14.

17. *Eunotia* 4, 13, 14.

18. *Plagiogramma* 4.

20. *Triceratium* 4.

D. Desmids

1. *Cosmarium* 3.

2. *Closterium* 2, 5, 8, 9, 13, 14, 15.

II. Protozoa

A. Amoeboid

1. *Actinosphaerium* 3.

2. *Amoeba limax* 1, 13, 14.

3. *Amoeba* 3.

4. *Acanthocystis* 13.

5. *Noclearia* 2, 3.

B. Flagellate

1. *Euglena* 5, 6, 7, 13, 14, 15.

2. *Peranema* 6, 7.

3. *Notosolemus* 6.

4. *Eutreptia* 6.

5. *Atractonema* 7.

6. *Phacus* 7, 15.

7. *Astasia* 3.

8. *Cephalothamnium* 1, 13, 14, 15.

9. *Urceolus* 14.

10. *Heteronema* 14.

11. *Trentonia* 15.

C. Ciliate

1. *Vorticella* 1, 2, 5, 6, 8, 13, 14.

2. *Stentor* 13, 14, 15.

3. *Stentor polymorphus* 14, 15.

4. *Linotus* 14.

5. *Colpodium* 12.

6. *Leucophrys* 7, 14.

7. *Euplotes* 1, 3, 6, 8, 13, 14.

8. *Cinetochilum* 3, 4, 14.
9. *Cothurnia* 14.
10. *Paramoecium* 1, 2, 3, 6, 8, 15.
11. *Pleuronema* 2, 7, 8.
12. *Stylonychia* (long) 2, 3, 7, 8, 12.
13. *Stylonychia* (oval) 8, 15.
14. *Oxytricha* 5, 8, 10.
15. *Chilodon* 1, 3.
16. *Chaenia* 1, 2, 3, 6, 8, 11.
17. *Atractonema* 1.
18. *Ophryglena* 1.
19. *Frontonia* 1.
20. *Glaucoma* 2.
21. *Condyllostoma* 3.
22. *Coleps* 3, 8, 15.
23. *Colpoda* 8, 12.
24. *Metopus* 8.
25. *Halteria* 7.
26. *Spirostomium* 6.
27. *Blepharisma* 15.

28. *Opercularia* 15.

III. Rotifera

1. *Pleurotrocha* 8.
2. *Philodina* 6, 8.
3. *Gastropus* 1.
4. *Diplax* 3.
5. *Diplois* 1, 13, 14, 15.
6. *Branchionus* 5, 13, 14, 15.
7. *Rattulus* 14.
8. *Floscularia* 14.
9. *Diaschiza* 13, 15.
10. *Melicerta* 15.

IV. Gastrotricha

1. *Chaetonotus*

V. Crustacea

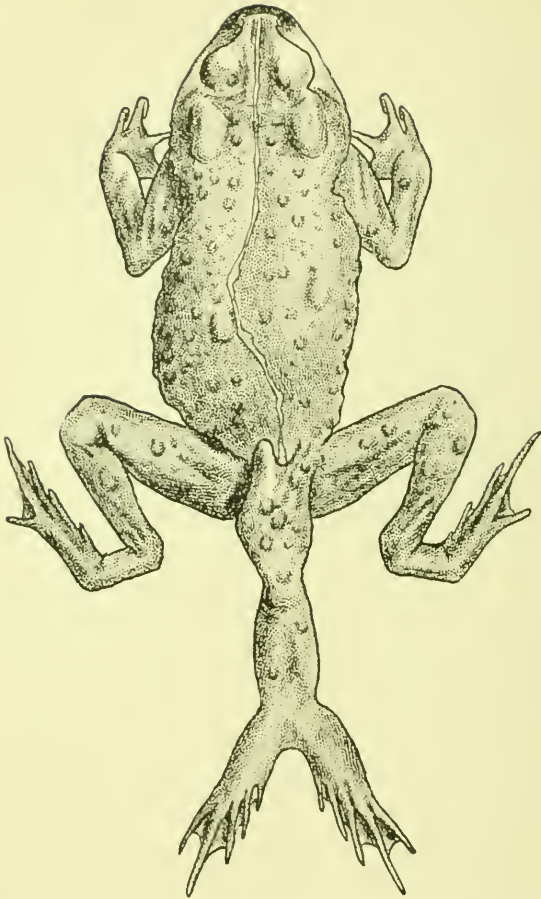
A. Ostracoda

1. *Cypris* 7, 9.
2. *Herpetocypris* 11.

B. Cladocera

1. *Alonella* 11.

(Contribution from the Zoological Laboratory of Pomona College.)



This peculiar toad was brought into the laboratory by Mr. M. Wyman. The drawing is by Mr. E. Crosswhite. The toad lived for some time and a few things were learned about its extra leg with the two feet.

1. It was capable of feeble movements of the leg and feet.
2. There was no true joint at the junction of the fifth leg with the body.
3. The extra leg was dragged along with no attempt made to use it in any way.
4. The extra leg could be used as a brace when the toad tried to climb from a jar.

(Contribution from the Zoological Laboratory of Pomona College.)

General Reactions of a Centipede

SUSIE CASE

This paper deals with the locomotion and general reactions resulting from experimentation upon the nervous system of centipedes. The nervous systems of these forms are very good for such experimentation, as the ganglia are distinct and widely separated.

There seem to be but three or four papers on the subject—two of these being on the physiology of the brain and *not* behavior, and one, "On the Movements of Millipedes and Centipedes" by E. Ray Lankester. I should like to mention several points which were observed along this last line. The locomotion of the centipede can be better emphasized by comparing it with that of the millipede. In the millipede one of the most apparent characteristics is the movement of the legs in waves, the pairs on opposite sides moving together, identically. The legs form groups of two pairs to a segment and these start the motion from the tail end forward. From five to eight distinct waves can be counted when all the legs are in motion. Millipedes move straight forward. On the other hand, the centipede as stated by Lankester, "contributes the serpentine stroke to the process of locomotion." It does not have the distinct waves mentioned in locomotion of the millepede. The legs on the opposite side do not move identically but are antagonistic in phase; and move in perfect harmony unless there be some injury to the nervous system, which controls locomotion. I agree with Lankester that it is most probable that the condition presented by the centipede in locomotion is a higher development than that shown by the millipede. The wave movement suggests a type found in lower invertebrates.

Th reverse locomotion of the centipede is very interesting. Most of them *persist* in going forward and yet in testing to find some definite result, I have discovered that occasionally they will, with persuasion, go backward. Most often, however, they turn the entire body instead of reversing the movements of the legs. On the other hand, all millipedes with persuasion will reverse for a short distance. When one goes backwards, it reverses the motion of the waves also, causing them to go from head to tail instead of from tail to head.

I have mentioned the two main observations of general behavior as to locomotion and shall now go on to the definite experiments which were made on the centipede to test specific reactions.

First as to the method: The specimen to be operated upon was pinned out on cork—the pins not being put through the centipede but across in a sufficient number of places to hold it firmly. The cut was made from the dorsal side into the nervous system. We tried not to make the external cut any larger than was absolutely necessary. When in doubt as to the position of the injury, we examined the animal after death.

The experiments and results are as follows:

Experiment I...Twelfth connective cut on right side. Results:

1. Some lack of movement in legs near cut and on same side, probably due to injury of muscles.

2. Tests to see whether stimuli carried from tail end to head end on injured side. Anal leg pinched. We have the suggestion in this that the impulse travels up and crosses over to the opposite side at the injured point, causing the head to turn to the right. On the uninjured side the impulse is able to travel up without crossing. The reaction was quicker than on the injured side.

3. Acetic acid on antennae of injured side. Reaction on opposite side at anal end first. Acetic acid on antennae of uninjured side. Reaction on same side at anal end.

4. When stimulated below cut, both sides respond equally well. All of these tests show that movement is deferred on the injured side.

Experiment II. Similar results obtained by cutting connective in fourteenth segment on right side.

Experiment III. Cut two connectives of twelfth segment. Results:

1. Specimen was turned on its back. It could turn over above injury without aid, was helpless back of injury.
2. Moved legs vigorously above injury; dragged others.
3. Antennae sensitive to touch, causing response back to injury.

Experiment IV. Results similar to experiment three obtained by cutting two connectives between last two ganglia.

Experiment V. Connectives cut between brain and sub-ganglion. Results:

1. Stimulated antennae. No response.
2. Stimulate anal leg. Impulse traveled along slowly, causing all legs to move. This seems to be a muscular reaction rather than one controlled by the nervous system.
3. One response in which I was very much interested was that the centipede, as a result of this particular experiment, reversed movement with apparent ease.

Experiment VI. Two alternating connectives cut. Results:

1. Specimen very active. Tests showed good crossing of sensation paths.

Experiment VII. Four cuts alternating excepting for second cut. Between cuts one and two connectives not severed on either side. Results:

1. Test to see whether stimuli carried to brain. Very slight stimulus at anal leg, caused only reaction in legs back of injury. Strong stimulus, caused stimulus to go to brain but it was very slow, due to the number of injuries. The stimulus had to cross at several points.
2. There is apparent separation of brain from anal end by injuries. The legs in front of injuries in constant motion, while those in back are quiet.
3. Stimulated head region. Result is a very active reaction, which takes place almost immediately, back to the injured part. There was much delay here. Gradually the response extended farther down.

Experiment VIII. Connective cut on left side in fifth segment from head. Connective cut on right side in fourth segment from tail. In this experiment I wanted to test for time of response when cuts are on opposite sides and quite a distance apart. Results:

1. Anal legs stimulated. On the right side it took longer for the response at the head end. On the left side it was carried immediately to brain. This was probably due to the position of the segment where crossing over took place.

2. Legs stimulated at center of body. Anal end drew up on the side stimulated. This reaction took longer on the right side, because the stimulus had to cross at the injury.

3. From the injury of the nervous system of the muscles, the specimen moved with a swinging motion. It could reverse its movements.

Experiment IX. About one-third of the brain was removed, the right connective was severed between the brain and the next ganglia, all connections with the eye were severed on the same side. Results:

1. No co-ordination of leg movement. Legs interfered with one another.

2. At first, no sense of correct position. As willing to stay on back as normal position.

3. Most noticeable result was that it reversed movement with apparently as much ease as it went forward. It traveled the length of the dish. This centipede lived twenty-four hours.

Experiment X. Removed sub and supra ganglia. Results:

1. Had better co-ordination of leg movement than one with one-third of brain removed (*Experiment IX*), however, it needed stimulation for movement. A slight jar of the dish was stimulus enough for the reaction. After this experiment the centipede lived sixty hours, thus showing the injury to be less of a shock than in experiment nine.

Experiment XI. The centipede was cut into nearly equal parts. This last experiment is of a different type but results are along the same line as others. Results:

1. In tail half there seems to be co-ordinated reaction of legs, suggesting that the symmetry has not been interfered with. It turns toward side stimulated. Tail end remained alive a little over two hours.

2. The head end was again cut into two parts. The central section was active and remained alive for two hours. The head end was very active. It had initiative to move without being stimulated, which power the other two parts did not have. The head end remained alive three hours.

GENERAL CONCLUSIONS

1. The head ganglia seem to be necessary to initiate movements.

2. The body ganglia are rather independent centers for local control, and complete co-ordination is possible without the head.

3. The stimuli travel up and down the nervous system, both on the side stimulated and on the opposite side.

4. In case a connective is served on one side, the stimulus is capable of crossing over to the other side but the reaction is somewhat delayed.

5. When alternate connectives are severed for some distance, the stimulus, although delayed, passes from one end to the other. The delay is increased according to the number of connectives severed.

6. Centipedes as compared with millipedes do not as a rule reverse the movements of the legs, but unilateral injuries to the brain seem to permit the reverse movements upon stimulation.

(Contribution from the Zoological Laboratory of Pomona College.)

Notes on the Central Nervous System of a Free-Living Marine Nematode

WILLIAM A. HILTON

The species studied was the one which is most abundant at Laguna Beach among Algae and in sand at low tide. It corresponds closely to *Enoplus brevis* Duj.

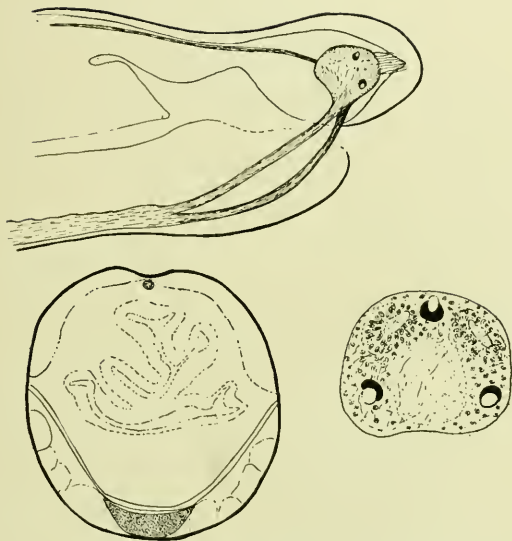
The nervous system has several features not described in related forms. There is a concentration of the central nervous system. There is a single large ganglion or brain in the snout above the mouth, from this two connectives pass ventrally to join the broad ventral nerve band in the mid-ventral line, while the only other longitudinal nerve noted was the very small mid-dorsal. Lateral nerves were not found.

The head or snout ganglion is provided with three eye spots, and unpaired dorso-median and a pair of latero-ventral ones. The sensitive region is so placed as to receive stimuli from above by the median eye and from below by the lateral eyes. The eyes are little more than concave pigment spots imbedded in the mass of the ganglion. A number of fibers pass from the ganglion forward to supply the thick sensory epithelium of the tip of the snout.

The ganglion is rather complex in structure. It has a central and somewhat ventral mass of fibers surrounded on all sides by nerve cells and fibers mingled. There are two centers composed each of cell areas surrounding a fibrous mass; these seem to be associated with fibers connected with the sensory epithelium of the snout and they resemble slightly the olfactory areas of certain invertebrate brains.

The dorsal nerve trunk is not cellular. The ventral nerve trunk is thick and broad. Ventrally it is nearly fused with the underlying cells of the body-wall, while dorsally it is bounded by a closely applied muscular layer. The nervous tissue itself is traversed by heavy lines which in part may be merely supportive in function, the lighter strands, both transverse and longitudinal, are branches from the rather abundant cells which are for the most part located ventrally.

(Contribution from the Zoological Laboratory of Pomona College.)



(FIG. 1.) EXPLANATION OF FIGURES

The figure above is a reconstruction of the head end of *Enoplus*, showing the position of the nervous system. The lower figure at the left is of a section through the whole body of the worm, showing the dorsal and ventral nerve bands. Both these figures enlarged 75 times. The drawing at the right is from a section through the head ganglion, enlarged 170 times. The dorsal side is up in all the figures.

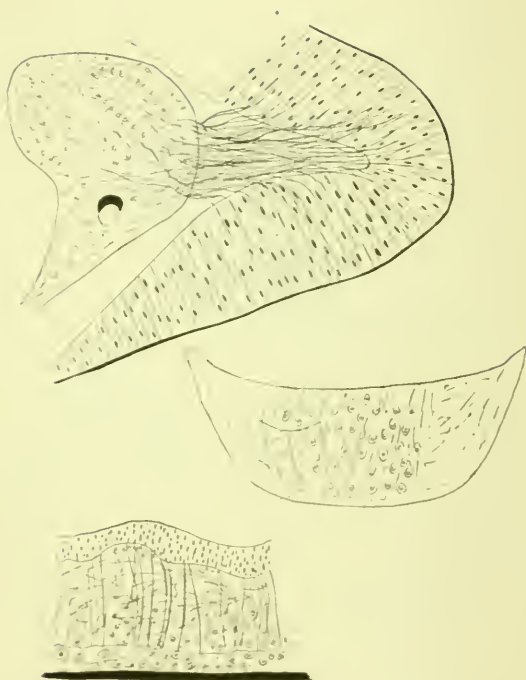


FIG. 2.) EXPLANATION OF FIGURES

The figure above is through the snout and ganglion of *Enoplus*. The central figure is a drawing of a cross-section of the ventral nerve band. The lowest figure is from a longitudinal section of the ventral nerve band with the muscular layer above and the body-wall below.

The dorsal side is up in all the figures and all are enlarged 255 times.

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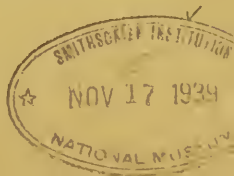
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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor

Claremont, California, U. S. A.

New Species of Crane-Flies from the United States and Canada

(*Tipulidæ*, *Diptera*).

By Charles P. Alexander, State Natural History Survey, Urbana, Illinois.

Most of the new species described in the present paper were found among material sent to the writer for identification. I am greatly indebted to Mr. W. L. McAtee and to Mr. F. R. Cole for the privilege of studying and describing many of the species included in this paper. Two interesting forms were collected in southern Illinois during the season of 1919 by Mr. Malloch and the writer.

Family Tipulidæ.

Subfamily Limnobiinæ.

Genus *Dicranomyia* Stephens.

Dicranomyia terræ-novæ sp. n.

General coloration gray, the præscutum with three dark brown stripes; antennæ dark brown throughout, the flagellar segments short-oval; wings with a heavy dark brown pattern, including five large costal blotches; *Sc* short, basal deflection of *Cu1* far before the fork of *M*.

Male.—Length about 5.5 mm.; wing, 7.6 mm.

Female.—Length about 7.5 mm.; wing, 7.7 mm.

Rostrum dark brown; palpi brownish black. Antennæ dark brown, the flagellar segments short-oval, clothed with an abundant pale pubescence. Head bright silvery on the front, duller on the posterior parts of the head; a conspicuous brown line on the vertex.

Pronotum dark brown. Mesothorax very deep, the mesonotum gibbous. Mesonotal præscutum light gray with three conspicuous dark brown stripes, the broad median stripe indistinctly split by a capillary line; scutum gray with the lobes dark brown; scutellum and postnotum gray, the latter with a delicate brown median line. Pleura light gray with an indistinct brownish longitudinal stripe extending backward from the fore coxæ; a similar line on the mesosternum. Halteres yellow, the knobs dark brown. Legs with the coxæ small, gray; trochanters dull yellow; femora brownish yellow, the tips indistinctly darker; tibiæ and tarsi brown. Wings whitish subhyaline with a heavy brown and grayish pattern, as follows: five dark brown blotches along the costal margin, the first near the wing-base, the third at the tip of *Sc* and the origin of *Rs*, the fourth at the tip of *R1*, the last at the tip of *R2+3*, suffusing the wing-apex; the first three of these markings reach the costa and pass into cell *R*; the fourth (stigmal) is rectangular, connected with a blotch at the fork of *Rs*; narrow brown seams along the cord and the outer end of cell *1st M2*; large brownish gray clouds along the margin at the ends of the veins and at the anal angle of the wings. Venation: *Sc* short, ending just beyond the origin of *Rs*, *Sc2* indistinct, apparently somewhat removed from the tip of *Sc1*, this distance about equal to the basal deflec-

tion of $M1+2$; basal deflection of $Cu1$ far before the fork of M , this distance about equal to the basal deflection of $M1+2$.

Abdomen dark brown, the posterior margins of the segments broadly silvery.

Habitat.—Newfoundland.

Holotype, ♀, Spruce Brook, August 8-12, 1912 (G. H. Englehardt), (No. F3192).

Allotopotype, ♂.

Paratopotype, ♀.

Type in the collection of the American Museum of Natural History.

Dicranomyia terra-noxæ differs conspicuously from all the described American species of the genus. Its vicarious Palearctic representative is *D. decora* (Staeger) of Northern Europe. Superficially it bears a marked resemblance to *Geranomyia rostrata* (Say), from which the structure of the mouth-parts and the slightly different venation will separate it.

Genus *Elliptera* Schiner.

Elliptera illini, sp. n.

General coloration brown, the pleura yellowish; cell $1st\ M2$ open.

Female.—Length about 5 mm.; wing, 6 mm.

Rostrum pale brown, the palpi dark brown. Antennæ with the scapal segments pale yellowish, the flagellum black; flagellar segments oval with a sparse white pubescence and verticils that are a little shorter than the segments. Head dark brownish black.

Thorax dull yellow, the thoracic dorsum with the stripes brown and entirely confluent, shiny, only the lateral margins of the præscutum yellowish. Halteres dark brown, the base of the stem more yellowish. Legs with the coxæ and trochanters dull yellow; remainder of the legs brown, the base of the femora paler. Wings gray, the stigma indistinct; veins dark brown. Venation: Sc rather short, ending about opposite two-thirds the length of the long sector; $Sc2$ proximad of the origin of the sector, the distance about equal to the basal deflection of $Cu1$; basal deflection of $R4+5$ almost square and in one wing of the type strongly spurred at the angle; cell $1st\ M2$ open by the atrophy of the outer deflection of $M3$, $M1+2$ before m about one-half that beyond this cross-vein; basal deflection of $Cu1$ just before the fork of M .

Abdominal tergites dark brown, the sternites yellowish.

Habitat.—Illinois.

Holotype, ♀, Makanda, Jackson County, June 4, 1919 (Alexander).

Type in the collection of the Illinois State Natural History Survey.

The unique type of *Elliptera illini* was found in the "Ozark" region of Illinois while Mr. Malloch and the writer were engaged in an entomological survey of this section. The genus *Elliptera* was hitherto represented by two species from Europe and two species from North America west of the Rockies. The occurrence of the genus east of the Mississippi River was quite unexpected and breaks the hitherto discontinuous distribution of this curious genus of crane-flies. The present species differs from its American relatives in the open cell $1st\ M2$, a character possessed by both of the European forms.

Genus *Orimarga* Osten Sacken.*Orimarga wetmorei* sp. n.

General coloration black; thoracic pleura and lateral margin of the præscutum striped with silvery; legs pale yellowish brown, the tips of the femora a little paler; wings subhyaline, the veins pale brown; tip of *R1* atrophied or indistinct; deflection of *R*†+5 very long.

Sex, female?—wing, about 4 mm.

The type is badly discolored. The general coloration is a dark brownish black; basal segments of the antennæ paler, the flagellar segments nearly globular.

The mesonotum has the extreme lateral margins of the præscutum narrowly silvery, the pleura with a broad silvery longitudinal stripe, this type of coloration being similar to that in *O. argenteopleura*. Legs light yellowish brown, the tips of the femora indistinctly paler; tarsi darker. Wings subhyaline, the veins pale brown, more yellowish along the costal margin. Venation: *Sc* moderately long, ending at about one-third the length of the long sector; *Rs* strongly arcuated at its origin; tip of *R1* atrophied or retreated back almost to the tip of *Sc1*; *r* very long and strongly arcuated; basal deflection of *R*†+5 very long, strongly arcuated at its origin, more than half the length of *Rs*; cell *M3* deep; *r-m* far beyond *r*.

Abdomen dark brownish black, the apex broken.

Habitat.—Florida.

Holotype, Sex?, Paradise Key, February 22, 1919 (Alex Wetmore).

Type in the collection of the United States Biological Survey.

O. wetmorei is the sixth American species to be described, the second from the United States. The fly differs conspicuously from *O. arizonensis* Coq. (Arizona) in the coloration of the legs and body and in the venation. It is much more like *O. argenteopleura* Alex. (Guatemala) which has the thorax similarly colored; this latter species is considerably larger, with dark brown legs and a very distinct venation (tip of *R1* short, persistent; basal deflection of *R*†+5 short).

The species is dedicated to the collector, Alex Wetmore.

Genus *Erioptera* Meigen.*Erioptera (Erioptera) oregonensis*, sp. n.

Size large (wing of the male over 7 mm.); general coloration brown, including the halteres; wings with a strong brownish suffusion.

Male.—Length, 6 mm.; wing, 7.3 mm.

Rostrum and palpi dark brown. Antennæ dark brown, moderately elongate, clothed with a dense white pubescence, the verticils of the more terminal segments very long. Head dark brown, more grayish brown around the eyes.

Mesonotum dark brown with indistinct stripes on the præscutum, the lateral margins of which are indistinctly paler; humeral angles not noticeably brightened; tuberculate pits small, widely separated; scutum, scutellum and postnotum sparsely yellowish gray pruinose. Pleura dark brownish black, gray pruinose. Halteres long and slender, dark brown, only the base of the stem a little brightened. Legs with the coxæ dark, grayish pruinose; remainder of the legs dark brownish black, only the trochanters and the bases of the femora a little brighter. Wings with a strong grayish

brown suffusion; stigma dark brown; an indistinct brown cloud along *r-m* and the deflection of *R*+5; veins dark brown. Venation as in the subgenus, the 2nd *Anal* vein strongly sinuate.

Abdomen dark brownish black with a paler brown pollen. Hypopygium a little brighter; pleurites short and stout, sparsely setigerous; two pleural appendages, the outer appendage larger, the outer end flattened and enlarged, along the margin with four parallel rows of fine comb-like points; inner appendage paddle-like, the blade suddenly enlarged, provided with a few setigerous punctures, at the extreme tip with an additional, powerful, curved bristle. Penis-guard straight, tapering gradually to the blunt tip; gonapophyses with the apices produced laterad into conspicuous triangular blades with the points directed laterad.

Habitat.—Oregon.

Holotype, ♂, Tillamook, March 26, 1919, (A. C. Burrill).

Genus *Ormosia* Rondani.

Ormosia subcornuta, sp. n.

Belongs to the *meigenii* group; closely allied to *O. cornuta* (Doane) but the veins stouter, the stigma distinct, and the details of the male hypopygium very different.

Male.—Length, about 3.5–3.8 mm.; wing, 4.3–4.7 mm.

Female.—Length, about 3.8–4 mm.; wing, 5 mm.

Rostrum and palpi dark brown. Antennæ moderately elongate, dark brownish black, the scapal segments slightly paler brown. Head gray, provided with conspicuous yellow setæ.

Thoracic dorsum brownish gray without distinct stripes, the lateral margins more yellowish; tuberculate pits shiny black, located close together, the distance between them less than the diameter of one. Pleura brown with a strong gray pruinosity; a large tuft of yellow setæ between the base of the wings and the base of the halteres and a second group immediately ventrad of the halteres. Halteres yellow. Legs with the coxæ dark, gray pruinose; trochanters dull brown; remainder of the legs dark brown, the bases of the femora a little brighter. Wings subhyaline; stigma large, dark brown; veins stout, dark brown. Venation: cell 1st *M*2 open by the atrophy of the outer deflection of *M*3; 2nd *Anal* vein slightly sinuous on its distal half, converging toward the 1st *Anal* vein.

Abdomen dark brown. Male hypopygium with the pleurites stout, provided with numerous conspicuous setigerous tubercles that bear long yellowish setæ which become more elongate and stouter toward the tips of the pleurites; outer pleural appendage subglobular, armed with from 4 to 8 powerful, acute spines, the terminal spine large, along the outer face with microscopic, appressed denticles, the basal spine on the inner side of the appendage largest, strongly incurved; inner pleural appendage long, slender, with a strong spine before the tip to produce a bifid appearance. The most lateral pair of gonapophyses are sinuous, with a group of two or three teeth or spines on the inner face some distance before the tip, the slender apex beyond these slightly curved; the proximal pair of gonapophyses are almost straight, very slender, the tip with numerous indistinct denticles, at the extreme base with a few conspicuous spines; an additional pair of gonapophyses whose apices are conspicuously flattened, with the point of the blade directed laterad and slightly cephalad. Ninth sternite

with a broad spatulate blade, as in the *meigenii* group of this genus, the apex deeply notched medially.

Habitat.—Oregon.

Holotype, ♂, Forest Grove, March 26, 1919, (F. R. Cole).

Allotopotype, ♀.

Paratopotypes, 2 ♂s; paratypes, 1 ♂, 1 ♀, Hillsboro, April 1, 1919, (F. R. Cole).

This little species is evidently the Western representative of the common *O. meigenii* (O. S.) of the Eastern States, its general appearance being very like that species. In the structure of the male hypopygium, however, it runs closes to *O. cornuta* (Doane), which may be told by the different color of the wings and the structure of the hypopygium.

Genus *Gonomyia* Meigen.

Gonomyia (Gonomyia) coloradica, sp. n.

Belong to the *blanda* group, closest to *mathesoni* Alex.; general coloration yellowish, the præscutum with three broad, confluent stripes of reddish brown; wings with the petiole of cell *M2* long; male hypopygium with the structural details very different from those in *G. mathesoni*.

Male.—Length, about 4.5 mm.; wing about 6 mm.

Rostrum, palpi and antennæ dark brown. Head dark.

Pronotal scutum and the collare dark brown; pronotal scutellum pale. Mesonotal præscutum with three broad, reddish-brown confluent stripes, the humeral regions cephalad of the lateral stripes pale; scutellum pale. Pleura pale, indistinctly striped with brown. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters pale; femora light brown; remainder of the legs broken. Wings subhyaline, unspotted; stigma lacking; veins brown. Venation: almost as in *G. mathesoni* with the following details different: *R2* very oblique and apparently contiguous with the tip of *R1*; *R2+3* not angulated before the middle of its length and without a faint spur of *r* at this point; petiole of cell *M2* much longer, one-half longer than the fused portion of *Cu1* and *M*.

Abdomen light brown. Male hypopygium generally similar to that of *G. mathesoni*, differing as follows: The bifid pleural appendage is very similar in the two species, in the present species with the needle-like tip of the longest arm abruptly pale. The long, sinuous appendage in *mathesoni* is here represented by two, the longer of which is pale throughout, flattened, the long tip acicular and almost straight; the shorter appendage is flattened, before the tip a little expanded, with a long, slender, curved black-tipped apex. Near the base of these pleural appendages is a flattened subtriangular lobe which is covered with an abundance of short setæ; in *G. mathesoni*, this appendage is very small, cylindrical, with but few setæ and with a distinct finger-like spinous lobe on one side. Penis-guard distinctly trifold at its apex, the lateral black spines directed almost caudad, setigerous at their bases; a shorter median pale lobe.

Habitat.—Colorado.

Holotype, ♂, Longview, June 24, 1916 (E. C. Jackson).

Type in the collection of the United States Biological Survey.

Genus *Phyllolabis* Osten Sacken.*Phyllolabis latifolia*, sp. n.

General coloration light gray; wings pale gray, the stigma pale grayish brown; $R2+3$ shorter than $R3$ alone; cell $1st\ M2$ short; male hypopygium yellow with the foliaceous appendage of the eighth sternite very broad and but indistinctly bifid at its tip.

Male.—Length about 6.5 mm.; wing, 7.5 mm.

Rostrum dark brown, heavily gray pruinose above; mouth-parts reddish brown; palpi dark brown. Antennæ moderately elongate, dark brown throughout, the flagellar segments long-oval, provided with venticils that are but little shorter than the segments. Head light gray with an indistinct black median line.

Pronotum rather large, heavily light gray pruinose. Mesonotal præscutum brownish gray pruinose without distinct stripes; pseudosutural foveæ black, short-triangular; tuberculate pits not evident; remainder of the mesonotum gray pruinose, the scutellum more brownish. Pleura clear light gray. Halteres pale. Legs with the coxæ and trochanters pale brownish yellow; remainder of the legs dark brown, the bases of the femora paler. Wings pale gray; stigma rather indistinct, pale grayish brown; veins dark brown; Sc and the abortive vein behind Cu more yellowish. Venation similar to *P. claviger* but $R2+3$ shorter, less than $R3$ alone; veins $R2$ and $R3$ more divergent, $R2$ at the wing-margin being distinctly closer to $R1$ than to $R3$; cell $1st\ M2$ shorter, especially the outer deflection of $M3$.

Abdomen brown, sparsely gray pruinose. Hypopygium light yellow, including the pleurites and pleural appendages. Genitalia similar to *P. claviger*, differing as follows: outer angle of the pleurite much longer, projecting conspicuously beyond the pleural appendages; dorsal pleural appendage not slender and strongly bent at mid-length but very broad and flattened, roughly subtriangular with the base narrowest. Foliaceous appendage of the eighth sternite very broad and flattened, widest at the base, thence with the sides almost parallel slightly expanded at the distal end, the caudal margin of this leaf-like lobe slightly concave, feebly or indistinctly notched medially.

Habitat.—Oregon.

Holotype, ♂, Forest Grove, March 28, 1919 (F. R. Cole).

Genus *Tricyphona* Zetterstedt.*Tricyphona sparsipuncta*, sp. n.

Close to *T. septentrionalis* Bergr.; median præscutal stripe split by a pale line; wings subhyaline, the costal region more yellowish; $r-m$ connecting $R4+5$ and $M1+2$.

Female.—Length, 7.5–8.8 mm.; wing 9.2–11 mm.

Rostrum very short, transverse, dark brown, sparsely gray pruinose, the anterior margin with a row of a few long yellowish bristles; mouth-parts and palpi dark brown. Antennæ dark brownish black, the basal four or five segments enlarged and very crowded as in this group of species. Head dark brown above, the front and a narrow margin around the eyes and across the anterior part of the vertex light gray.

Mesonotum very high and gibbous. Mesonotal præscutum light grayish yellow, with three dark brownish stripes, the median stripe split by an indistinct pale capil-

lary line that is more distinct in front; the sides of the median stripe are nearly parallel; lateral stripes narrow, their anterior ends subacute; scutum with the lobes marked with brown; scutellum light gray. Pleura dark brown, gray pruinose. Halteres pale yellowish brown, the knobs dark brown. Legs with the coxæ brown on the outer face; trochanters dull yellow; femora and tibiæ dull yellow, tipped with dark brown; tarsi dark brown, the base of the metatarsi paler. Wings subhyaline, the costal and subcostal cells more yellowish; stigma oval, dark brown, paler distally; sparse brown clouds along the cord, at the fork of $R\# + 5$, along the outer end of cell $1st\ M2$ and, less distinctly, at the base of the sector; veins dark brown, Sc more yellowish. Venation: The distance between $Sc2$ and the origin of the sector shorter than the straight portion of the sector alone; Rs angulated and spurred at its origin; upward deflection of $R2$ slightly oblique, inserted in $R1$ rather far before its tip, so that $R1 + R2$ is greater than the deflection of $R2$ alone; petiole of cell $R\#$ short, about one-fourth longer than $r-m$; $r-m$ inserted between $R\# + 5$ and $M1 + 2$; petiole of cell $M1$ longer than this cell.

Abdomen dark brown; valves of the ovipositor reddish brown, strongly compressed, slightly upcurved at the tip.

Habitat.—Oregon.

Holotype, ♀, Hillsboro, April 1, 1919 (F. R. Cole).

Paratype, ♀, Corvallis, May 14, 1917 (Moulton).

The type is much larger than the paratype but undoubtedly refers to the same species. The fly is closest to *T. septentrionalis* Bergr. (Alaska) in its spotted wings but may be distinguished by the colorational and venational details as described above.

Subfamily Tipulinæ.

Genus *Tipula* Linnæus.

Tipula mallochii, sp. n.

Belongs to the *submaculata* group; close to *T. submaculata* Lw.; male hypopygium with the horns of the tergite short, outer pleural appendage not bifid, gonapophyses short, eighth sternite with two powerful decussate bristles.

Male.—Length, 15 mm.; wing, 17—17.4 mm.

Female.—Length, 20 mm.; wing, 18.5—19 mm.

Frontal prolongation of the head brown, more yellowish above; palpi pale brown. Antennæ bicolorous, the flagellum with the basal enlargement of each segment black, the remainder light yellow, on the apical segments a little more infuscated. Head yellowish brown with a sparse grayish bloom; a capillary dark brown median line.

Mesonotal præscutum dull brownish yellow with four rather narrow reddish brown stripes, the remainder of the dorsum yellowish. Pleura pale yellow, whitish pollinose. Halteres pale, the knobs dark brown. Legs with the coxæ pale whitish yellow; trochanters yellow; remainder of the legs darker. Wings pale gray, the base of the wings and the costal region more yellowish; stigma brown; a brown cloud at the origin of the sector; tip of the wing indistinctly darkened; obliterative area before the cord in the base of cell $R2$.

Abdominal tergites dull brownish yellow, on the sixth to ninth tergites dark brown; the caudal margins narrowly, the lateral margins more broadly, silvery;

segments two to five with a narrow longitudinal brown sublateral streak; sternites brown, the caudal margins of the segments pale. Hypopygium generally similar to *T. submaculata*, differing as follows: Ninth tergite with the lateral horns very short and broad, the tips acute, not long and tapering as in *submaculata*; outer pleural appendage short and broadly flattened, the apex subtruncated, with a few coarse setigerous teeth, in *submaculata* this appendage is more slender, tapering to the acute point, at about midlength on the outer margin with a prominent spine to produce a bifid appearance; gonapophyses broad and flattened at the base, the slender tips short, not long and sinuous as in *submaculata*; eighth sternite with a pair of strong reddish fused bristles that are decussate, in addition to the smaller setæ. In the female, the sixth and seventh tergites are dark brown, the ovipositor acute, the tergal valves being especially long and slender.

Habitat.—Illinois.

Holotype, ♂, Alto Pass, Union County, June 5, 1919 (Alexander).

Allotopotype, ♀.

Paratopotypes, 4 ♂ ♀; paratypes, 20 ♂ ♀, Makanda, Jackson County, June 4, 5, 1919 (Alexander and Malloch); 5 ♂ ♀, Dubois, Washington County, June 3, 1919 (Malloch).

Type in the collection of the Illinois State Natural History Survey.

Tipula mallochii is common in the "Ozark" region of southern Illinois during early June, when it flies with other species of the genus as *T. submaculata* Lw., *T. tuscarora* Alex., *T. translucida* Doane, *T. morrisoni* Alex., *T. mingwe* Alex., *T. umbrosa* Lw., *T. flavoumbrosa* Alex., *T. fuliginosa* Say, and, in proximity of low wet cliffs, with *T. ignobilis* Lw.

Notes on Pacific Coast Pycnogonids

W. A. HILTON

The specimens reported on at this time were obtained at Laguna Beach in the summer of 1920. Their collection was more or less incidental to other littoral explorations. There is also included a list of forms obtained at other times and at other places, chiefly during the same summer at Pacific Grove.

Pallene californiensis, Hall.

Two of these were collected at Laguna Beach.

Lecythorhynchus marginatus, Cole.

Twelve specimens collected at Laguna Beach from among mussels, under rocks, among algae, etc. One specimen was dredged of San Diego in 1916. Thirty-four were collected on the land side of Catalina Island at the Isthmus in quite a different type of locality from that which is usual. At this place there were few red Algae but masses of a rather fine brown rock-weed. On these plants, hydroids and bryozoans were quite abundant. Many more might have been collected if there had been time.

Among Algae in front of the Hopkins Laboratory at Pacific Grove 18 specimens of this species were found. One was collected at the "Big Tide Pool."

Ammothella tuberculata, Cole.

Twenty specimens found in front of the Hopkins Laboratory at Pacific Grove. One found at low tide in the "Big Tide Pool." None found at Laguna this season.

A. bi-unguiculata, Dohrn, var. *californica*, Hall.

Twelve of these obtained at Laguna Beach under stones. Three specimens at the Isthmus, Catalina Island.

A. spinosissima, Hall.

Seven specimens collected at Laguna Beach. Two obtained at Pacific Grove in front of the laboratory.

Tanystylum intermedium, Cole.

Twenty-five specimens from Laguna Beach.

Clotenia occidentalis, Cole.

Ten specimens from Laguna Beach. Sixty-three specimens from in front of the Hopkins marine station, some were found on plume hydroids and among Algae.

Halosoma viridintestinalis, Cole.

We usually find a number of this species at Laguna Beach but none were found this season. At Pacific Grove 68 were collected from masses of fine bryozoans from floating timbers.

Amoplodactylus erectus, Cole.

Specimens of this species may be obtained at Balboa among tubularian hydroids, a hundred or more were collected from this locality this year and one from Anaheim Landing with palm hydroids.

A. californicus, Hall.

Three specimens from Laguna Beach, 6 specimens from the Isthmus, Catalina Island, 1 specimen in front of the laboratory, Pacific Grove.

Pycnogonum stearnsi, Ives.

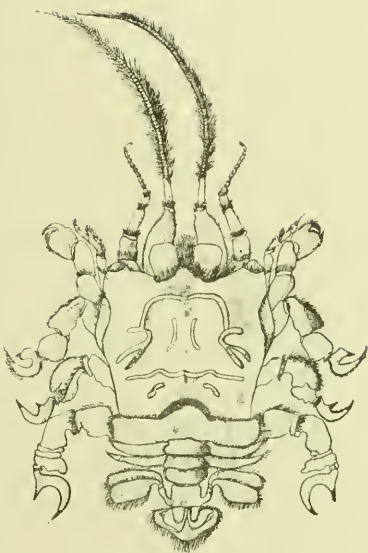
Seven specimens from Laguna Beach, 1 specimen from Pacific Grove.

(Contribution from the Zoological Laboratory of Pomona College)



Uca musica. Rathb.

Drawn by J. Caldwell from specimens obtained by Caldwell and Miss W. Durant at Balboa mud flats during the summer of 1920. This is the first record of a fiddler crab in our region. The male is shown with the large claw. Sometimes the large claw was on the right, sometimes on the left. Specimens brought to the laboratory in moist sand made their burrows and lived all summer. In spite of the larger claws of the males they gave way to the females when in each other's way.



Lepidopia myops, Stimp.

From Laguna Beach. Drawn by Joseph Caldwell.



Eremita analoga, Stimp.

Common sand crab of Laguna Beach. Drawn by Howard Lorbeer.

The Nervous System and Sense Organs

BEGINNING WITH THIS ISSUE A SERIES OF ARTICLES
WILL RUN FROM NUMBER TO NUMBER
WITH CONTINUOUS PAGING

By WILLIAM A. HILTON

I. Plants

One of the common properties of living things is irritability. All living substance reacts, responds to stimuli, whether they come from the outside or from within. Transmission of stimuli is also a common property of living matter.

Plants are sensitive to many sorts of stimuli without much indication of organs of special sense. Only in certain cases are there tissues for the transmission of the effects of stimulation and central organs for coördination and control seem to be entirely lacking.

In unspecialized organisms, both plants and animals, the surfaces are sensitive to many sorts of stimuli without special organs for their perception. The whole surface or the whole body may in a general way be sensitive. If there are special parts associated with special stimuli, there are no histological features to indicate them. This diffuse perceptive capacity is more characteristic of plants than animals, yet some animals are of this type, and many plants have structures which are truly organs of sense, and in some cases special tissues for the transmission of the effects of stimulation.

In certain parts of most plants there are areas of surface where the perception of stimuli takes precedence over the protective or other functions; such surfaces may be called sensory. Certain cells or cell groups in plants which have perception as their chief or only function may be called sense-organs, even though they may not be responsible for sensation in the psychological sense. So far as we know, plants have developed sense organs only in relation to a few forms of external stimulation, such as those of contact, shock or jar, gravity or static and photic or light stimuli. So far as we can tell, the real act of perception, so-called, always takes place within the living substance, mainly or entirely in the solid portions, or in the ectoplast.

Tactile pits occur in the outer walls of some surface cells. The cell walls are thin at these points, which are just over the sensitive protoplasm within the cells. These pits are usually confined to the sides of tendrils which may come into contact with surfaces. Darwin first determined that tendrils can be stimulated only by contact with, or friction against, solid objects, not by the impact of water.

Tactile papillae, knobs and hairs occur on various parts of plants, such as staminal filaments. Parts of flowers which exhibit movements are often stimulated by means of hairs or knobs. Movements of parts of insectivorous plants are initiated by means of special sensory structures, such as hair, knobs, or spines.

Plants respond to light in general without special organs of sense, but it is probable that the epidermal cells of many leaves are

arranged in such a way as to favor the reception of light waves. This is, of course, not alone for sensation, yet sensation may be an important function. Some epidermal cells bulge considerably, especially in the velvet-like leaves of tropical forests. Such elevations make it possible for the cells to perceive photic stimuli, even when their surfaces are wet. Sometimes a whole cell bulges in a lens-like manner; sometimes the wall is thickened like a little lens, and by these methods the rays of light are brought to a focus upon the inner sensitive protoplasm. In many plants the whole upper epidermis is developed as a light-perceiving or photic epithelium. Also at times the margin or some definite locality has cells especially adapted to focus and receive rays of light. Such cells alone or in groups are conical with rounded tips, the apex of each has its wall thickened or almost biconvex. Such so-called ocelli have been proved to condense the light more effectually than the ordinary surface cell.

Stigmata or eye spots are found in certain plant spores and among the flagellates, such as *Volvox*, *Euglena*, etc. In *Euglena* the light-perceiving ability is confined to sensitive protoplasm near the pigment spot. The eye spot or pigment therefore acts as a light-screen.

Geotropic movements of plants are remarkable. The plants of high organization especially seem sensitive to the stimuli of gravity. Certain cells of roots, stems and leaves are provided with movable starch grains. It has been suggested that the movements of these starch grains bring about changes for growth and movements appropriate to the needs of the plants.

Transmissions of stimuli take place within cells from the points stimulated to more distant portions, but they cannot well be determined. When the sensory and the reaction organs are more widely separated the conduction is more obvious. In plants there are but few examples of transmission at a distance, for in many cases of marked movements in plants the sensory areas immediately adjoin the motor tissue. In other cases the transmission is at a greater distance. The velocity of transmission in plants is much lower than in animals. Heliotropic and geotropic stimuli are said to require five minutes to travel two millimeters, traumatic stimuli: 1-2 cm. per minute to 1-2 cm. a second. In case of the sensitive plant the transmission is 30-100 mm. per second.

Besides the transmission of impulses through the protoplasm of the cell there is the necessity for transmission from cell to cell. No special pathways have been clearly determined for the first in plants, but protoplasmic threads traverse the whole thickness of the cell walls. It is questionable whether there are special structures within plant cells for the conduction of stimuli. Strands between cells have been interpreted by some as the pathways of the effects of stimulation. There is no central organ of coördination known

and no distinction is needed between afferent and efferent pathways.

The only instance known of special tissues for the conduction of impulses is in the sensitive plant group and here it is quite definitely proved that living tissues are not necessary for the conduction of impulses and are in no sense comparable to the conductive tissues of complex animals.

II. Protozoa

In *Amoeba*, there seems to be no portion of the surface more sensitive than others. The exoplasm is a general sensory organ.

Experiments by Hyman '17, with toxic substance show that a local region of increased susceptibility exists along the axes of each pseudopodium from its distal to its proximal end, the distal end being more susceptible. The youngest and most vigorous forms are most susceptible.

According to several investigators, the exoplasm of *Amoeba* is like a tough skin and this in part at least acts as a sensory area. The more fluid endoplasm may become quite rigid under stimulation.

The changes in *Amoeba* which are the causes of amoeboid movement and behavior originate within the *Amoeba* and external stimuli do not act directly to produce those physical alterations which result in movement, but they act through the protoplasm of the *Amoeba*. The reactions of *Amoeba* are similar to the reflexes of more complex forms involving reception of stimuli, and the conduction of internal changes leading to response, but sensation, conduction and movement are not differentiated.

If one side of an *Amoeba* touches some object it may move away from the source of stimulus. Jennings has found that when touched the animal does not usually move directly away from the side stimulated, but merely in some other direction. If the anterior edge is touched this part stops and contracts while the current turns to one side at this point, so that the animal moves at an angle with its former direction. If the advancing edge of an *Amoeba* is touched it withdraws and a new pseudopodium is sent out elsewhere. Sometimes *Amoebae* react positively to solid bodies, they may also under various sorts of stimuli thrust out many pseudopodia at once or draw all into a compact mass. *Amoeba* reacts not only to mechanical but also to chemical, temperature, light and electrical stimuli. The direction of movement in negative reactions is not determined entirely by the position of the stimulating agent. Other stimuli may have already altered the character of the protoplasm, for example the moving *Amoeba* is temporarily differentiated, having two ends different and the sides differing from the ends. These and perhaps other internal factors have a large part in the determination of movement.

It is impossible to explain how *Amoeba* alters its own metabolic process. If *Amoeba* is capable of self stimulation then this might suggest that living substance has a psychic quality which is possessed by all protoplasm. If this is not accepted for simpler organisms it would be hard to accept it for the cells of the cerebral cortex of man and all would be referred to present or past conditions of external or internal environment.

There is no clear evidence that *Amoeba* has memory. The

nearest approach to a suggestion of it comes from the observations of Jennings upon an *Amoeba* which attempted to devour one smaller. The ingested specimen escaped its captor, the larger reversed its movements and followed the smaller and again took it in. The behavior of the larger might seem to be partly determined by its earlier experience, but this might also be explained by a purely physical stimulus of a direct character.

Any elements of psychical qualities which *Amoeba* might pos-

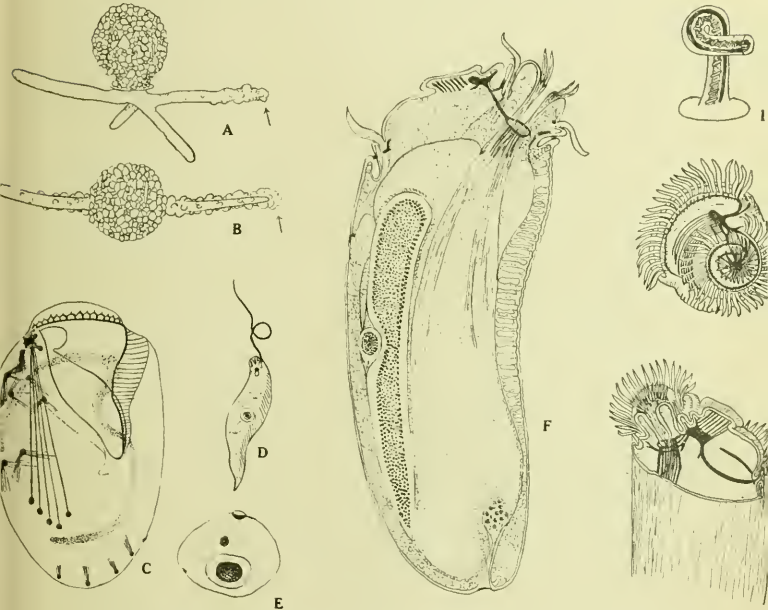


Fig. 1. NEUROMOTOR SYSTEMS AND SENSORY SYSTEMS OF PROTOZOA. A, B. *Difflugia* showing the effects of stimulating the ends of the pseudopodia. Verworn. C. Neuromotor system of *Euplotes*, Yocum. The motorium is dark, strands to the organelles and to the cirri shown by lines. D. *Euglena* showing eye spot near gullet and flagellum. Kent. E. *Gonium* showing eye spot above. Mast. F, G and H. Neuromotor system in *Diplodinium* after Sharp. The dark lines show the location of the chief parts of the system. F. Ideal section of the whole. G and H. Views from side and mouth end. I. Stem of *Vorticella* after Delage et Herouard, the contractile portion shown in dark, the conductive part in lighter.

sess are not capable of demonstration or proof. All that we can see is that if there are any elements of consciousness they must be of a very vague and elementary nature.

All forms of protoplasm have the property of irritability and there is usually also involved a certain degree of conductivity, but these are not always possible to measure or clearly determine. Verworn has made a study of conductivity in the elongated thread-like pseudopodia of some rhizopods. In studying the changes which take place in the long protoplasmic extension of *Diffugea* the results of stimulation may be directly observed. A weak stimulation at the end of the pseudopodium causes a slight wrinkling of the smooth surface, a stronger stimulus causes more swellings and more distant ones on the slender appendages. Fig. 1, A, B. The extent and rapidity of the wrinkling of the surface is in direct response to the strength of the stimulus applied. Other species of rhizopods gave similar results. The decrement of the intensity and rapidity becomes greater with the distance from the point of stimulation until the wave of excitation is obliterated. This is of course in sharp contrast to the conduction of a nerve fiber which normally conducts excitations without perceptible decrement of the intensity.

An organ for the control of amoeboid movement has been suggested, a centrosome or blepharoplast from which strands radiate to all the parts of the body which are concerned with locomotion, but no recent proof of this suggestion has come to my attention. According to Hyman the nucleus in *Amoeba* plays an important part in amoeboid movement, as is shown when the nucleus is removed.

Ciliate Protozoa such as *Paramoecium*, *Stentor*, *Vorticella*, etc., have much more complicated reactions than *Amoeba* because of their more complex structures, but the stimuli to which they respond are not much more complex or varied. The cilia are often highly specialized and localized; some coördination must be necessary. Cilia in general have been described in various ways as associated with small granules at their bases and strands from these granules have been described as penetrating into the cells, in some cases at least to be associated with a body of nuclear or cytoplasmic origin.

In 1880 Englemann found fibers in *Stylonychia* to which he assigned a nervous function. Neresheimer, 1903, found similar fibers in *Stentor*, and a number of others have described such structures without always being clear as to their function. Sharp, 1913, considers an elaborate system in *Diplodinium* which he calls a "neuro-motor apparatus." From a well-marked central body or "motorium" strands of substance were found going to the cilia and to various parts of the body in a complex manner. Fig. 1, F, G, H. Yocum, 1918, describes and figures a neuromotor system in *Euplotes*, developed from the ectoplasm. Fig. 1, C. It consists of

strands running from the motorium to sensitive areas, to the membranelles and to the long anal cirri. There are also strands connected with frontal, ventral, and marginal cirri, although these are not connected with the motorium. These cirri are irregular in their movements while the anal cirri are used chiefly in locomotion. These last as mentioned, have definite connections with the motorium. Yocum traces the homology of the motorium with the blepharoplast of many forms. This is the coördinating structure which serves to regulate anterior and posterior regions

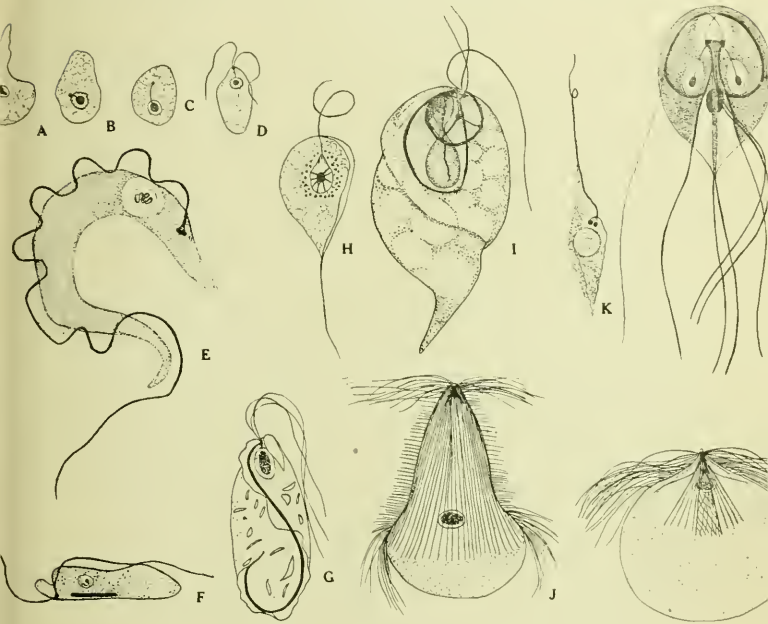


Fig. 2. NEUROMOTOR SYSTEMS OF FLAGELLATES. Nuclei and neuromotor apparatus mostly shown by dark lines or masses. A-D. Origin of blepharoplast from the nucleus in *Naegleria*. x 1040. E. Flagellate after Robertson. x 1200. F. *Trypanoplasma* after Martin. G. *Trichomitus* after Kofoid and Swezy. x 800. H. *Cercomonas* after Wenyon. I. *Chilomastix* after Kofoid and Swezy. x 3185. J. *Trichonympha* after K. and S. x 150. K. *Crithida*, after McCulloch. x 1440. L. *Leidyopsis*, Kofoid and Swezy. x 200. M. *Giardia*, Kofoid and Christianson. x 2550.

of the body. The basal granules of cilia, cirri, and membranelles are considered as secondary rather than primary structures. In ciliates the connection between neuromotor apparatus and cilia is not clearly established, but there is some indication that there may be connection.

In many flagellate protozoans the flagellum has been described as springing from a center or blepharoplast. A very primitive type of neuromotor apparatus is described by Wilson, 1916. The flagellum arises from a blepharoplast which grows out from the central karyosome (Fig. 2, A-D). The blepharoplast is connected with the karyosome by a rhizoplast.

In other forms the blepharoplast may be composed of one or more granules which may or may not be connected with the nucleus. The basal granule of the flagellum may have a double function of being a basal granule of the flagellum and also a division center for the cell. In some forms the two functions are separated in two granules. In some a number of granules surround the blepharoplast or may be derived from it. These migrate backwards and come to form the parabasal body which may in some cases be attached by a number of fibrils to the blepharoplast. This parabasal body is interpreted as an accessory kinetic reservoir. A further elaboration of this structure is the chromatic rod of some species.

Various types of flagellates with their internal connections are shown in Fig. 3. One of the most complex conditions we find in *Giardia*, Kofoid and Christianson, 1915. This is a binucleate organism equivalent to two flagellates, each containing one nucleus and one blepharoplast at the end of a single axostyle, three flagella and a half or whole axostyle, depending upon the stage of the organism. Two blepharoplasts are connected by cross commissures and are anterior. The lateral flagella cross the middle line. The blepharoplasts are joined to the nuclei by rhizoplasts and also to the parabasal body lying along the axostyle. Each organism has its own neuromotor apparatus, but due to the crossing of the fibers between the blepharoplasts the two organisms are unified. (Fig. 2, M.)

According to Yocum and others the motorium of ciliates is homologous with the blepharoplast of flagellates. According to Dobell the blepharoplast of the protozoan is homologous with the end knob and the axial filament of the metazoan sperm, whose function is to provide for the locomotor activities of the cell. These structures are also homologous with the centrosome of resting cells.

It seems probable that other strands and coördinating centers may be found in protozoans in addition to those already described. This type of system for control or coördination is not in any sense homologous with that of Metazoa and in no sense does it lead to development of the nervous system of more complex forms. From what has already been said it is probable that methods of coördination are not at all alike in Protozoa and Metazoa; in fact it may well

be that the method in rhizopods may be of quite a different character than in the more specialized Infusoria and Mastigophora.

It is quite interesting that the neuromotor apparatus is derived from the ectoplasm. This corresponds to the probable conductive tissues in the protoplasm of plants and suggests a comparison between the origin of these parts, with the origin of the nervous system of Metazoa from the ectoderm.

Special sense organs in Protozoa are rare. In certain forms there are eye spots or masses of pigment as in *Euglena*, Fig. 1, D. and there are also eye spots or sensory areas in such forms as *Gonium*. Fig. 1, E.

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III. The Sponges

The only activities of sponges which are in any way suggestive of sense organs or a nervous system are those connected with the water currents which enter and leave.

The currents are caused by collar cells distributed in the various chambers. These flagellate cells cause the continuous movements of the liquids under ordinary conditions. The flagella of these cells are connected with basal granules or blepharoplasts in each case and in some, connections are also made with the nucleus. Fig. 3, I, J.

Lendenfeld, 1885-7, has described sensory cells and ganglion cells in sponges, Fig. 3, E, F, G, but Minchin, 1900, and others believe there are no true nervous elements. No modern work has suggested the possibility of nerve cells or sense cells in Porifera.

Parker, in 1910, describes elongated spindle-shaped cells arranged like irregular sphincters around the gastral cavity, osculum, etc. Structurally they have the appearance of a primitive

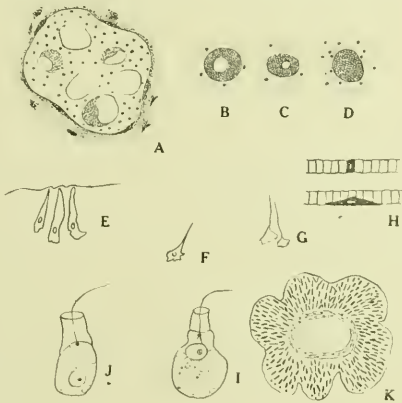


Fig. 3. STRUCTURES FROM SPONGES. A. Dermal membrane of a sponge seen from the exterior. Membrane pierced by six pores, three of which are partly closed by pore membranes. After Wilson, after Parker. B, C, D. Three stages in the closure of the membrane pore. After Wilson, after Parker. E, F, G. Sense cells and nerve cells, (?). After von Lendenfeld. H. Two stages in the development of a muscle cell as the first stage in the development of the nervous system. Diagram after Parker. I, J. Collar cells from sponges. After Robertson. x 1,000. K. Transverse section of the base of an oscular collar of a sponge showing the cavity surrounded by a sphincter of myocytes, spicules outside. Modified from Parker.

kind of smooth muscle fiber. As a result of their contraction the opening into the sponge is lessened or closed.

Wilson, 1910, describes membranes covering the subdermal cavity and containing pores. This so-called membrane is composed of an external portion and is believed to be syncytial. There are two somewhat independent devices for the closure of pores, the pore membrane and the pore canal sphincter. The closure of the pore canals is dependent upon the sphincter-like band of cells on the wall of the canal. These cells are in every way comparable to a primitive form of smooth muscle-fiber. They are in contact with the water passing into the canal and seem capable of direct stimulation. The pore membrane is less muscle like and is perhaps of a more primitive type.

Parker, 1910 and 1919, considers the sponges as an important group in illustrating the most primitive condition of the nervous system of metazoans. Muscle cells the independent effectors, as illustrated by the sphincters of sponges, were the first neuromuscular organs to appear. The special receptors in the way of sense-cells were next to appear in certain coelenterates while in other forms more complex, the adjuster or central organ was added.

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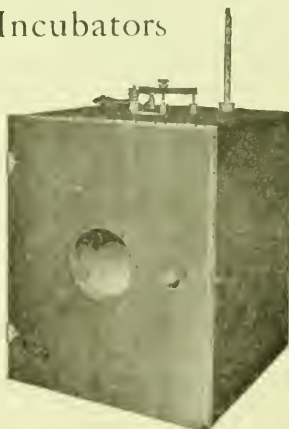
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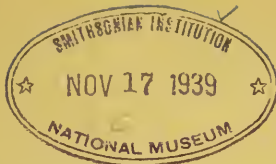
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Journal of Entomology and Zoology

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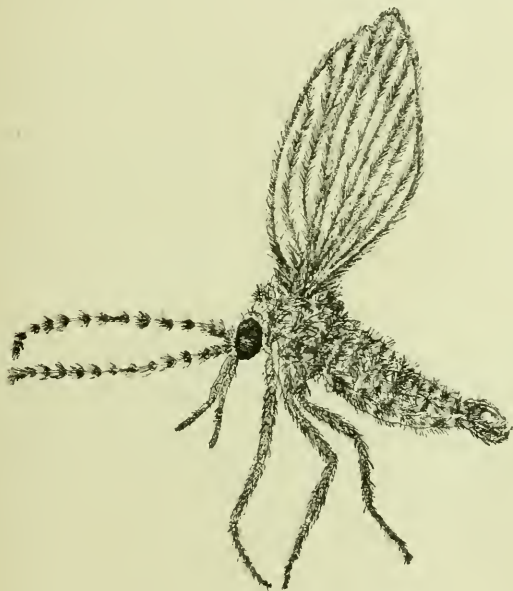
William A. Hilton, Editor

Claremont, California, U. S. A.

A Note on a Local Member of the Family Psychodidae Dip

Ella Gemmell

A number of specimens were collected about a drain in a house in Claremont. As they had not been seen here before and as there was no known standing water near, it was a question as to where they had passed their earlier stages. All the specimens were collected in or near the outlet to the small sink. Afterwards it was



found that the cesspool was nearly filled and a new one had to be made, after this the flies disappeared until once again when the cesspool was filled the flies appeared in the house.

These specimens were determined to be *Psychoda cinerea* Bks. this being the synonym for *P. pacifica* as described by Kincaid. The specimens agree in most all parts to Kincaid's description. The specimens were 2 mm. in length. The figure is from a male.

Littoral Ophiurans at Laguna Beach

ARTHUR S. CAMPBELL.

During the summer of 1920 specimens of all species of ophiurans previously known to exist near Laguna were obtained.

Several stations were found to be constant with the various species, some for adults, and others for young. Several are limited to very special habitats. Two are limited to but one locality each, while *O. spiculata* is found abundantly in almost all stations examined. For the first time *O. maculosus* was found inshore under stones; previously this species had been known only from kelp holdfasts.

The excellent plates for this paper are the work of Miss E. Keyes, a student in Pomona College.

OPHIODERMATIDÆ

No dental papillæ. Buccal papillæ numerous. Two or four genital bursæ in each interradius.

Ophioderma panamensis Lütkin.

Add. Hist. Oph., 2, p. 193. 1859.

Large. Arms, three or oftener four times diameter of disc. Mouth papillæ and teeth small. Arm spines numerous, flattened, lying close to arm. Color dark brown above, lighter below, the arms encircled by pale bands.

Young in *Macrocystis* holdfasts. Adults in rocky tidepools among *Fucus* and green algæ, ranging up to middle littoral tide pools. Common.

Ophiocryptus maculosus Clark.

Third Laguna Report of Pomona College, p. 64. 1915.

Small. Disc covered with swollen plates concealed by rough granules. Upper arm surfaces more or less covered by granules. Oral shields except madreporite, adoral and oral plates covered completely by granules continuous with above. Five almost conical, subequal arm spines. Two tentacle scales. Color white, grey or with disc marked with reddish granules. Disc in young is red, becoming marked later only by a few red granules, and finally dirty white in adult. Seventeen arm joints. Arms one and a half times diameter of disc.

In *Macrocystis* holdfasts, washed inshore under loose rocks. Young and adults intermingled. Rare.

OPHIOLEPIDÆ

No dental papillæ. Three or six buccal papillæ. Always two genital bursæ. Disc notched. No tooth papillæ.

Ophioplocus esmarki Lyman.

Bull. M. C. Z. 3, pt. 10, p. 227, pl. 5.

Medium size. Arms nearly three times diameter of disc. Three arm spines. Disc with plates on both surfaces. Disc and arms flattened. Color light or dark brown, some blue-grey.

Young in *Macrocystis* holdfasts, in calcareous sponges and among red algæ in tide-zone. Adults in rocky tidepools among *Fucus* and green algæ; in sand under loose rocks. Abundant.

AMPHIURIDAE

One to five mouth papillæ. Arms arising from ventral side. Two genital bursæ.

Amphiodia barbaræ Lyman

Ill. Cat. M. C. Z. Harvard, 8, pt. 2, p. 17, pl. 3. 1875.

Medium size. Arms twelve or more times diameter of disc. Oral papillæ six, equal and regularly arranged. Teeth. No tooth papillæ. Two short, flat tentacle scales. Three tapering arm spines. Color yellowish or tinged with green.

Deep in sand at Balboa. Young in sandy pool on shells. Rare.

Ophionereis annulata Le Conte.

Proc. Acad. N. Sc. Phila., 5, p. 317. 1851.

Medium size. Arms about six times diameter of disc. Mouth papillæ numerous. Teeth. No tooth papillæ. Three flattened, stout arm spines. Color light, arms distinctly banded.

Young in sponge masses. Young and adults among beds of *Mytilus*, *Lepas* and *Mitella*; in sand under loose rocks, and in rocky tidepools among *Fucus* and green algæ. Common.

OPHIOMIDAE

Mouth papillæ. Teeth. Arms arise from ventral side of disc. Two genital bursæ. Mouth shields small or medium.

Ophiopsis papillosa Lyman.

Ill. Cat. M. C. Z. Harvard, 8, pt. 2, p. 11. 1875.

Large and coarse. Arms three or four times diameter of disc. Disc completely covered above by stout stumps. Few mouth papillæ. Five flat, blunt arm spines. Color deep brown, arms often faintly banded.

In rock ledges with ground shell or sandy bases. Associated with the echinoid *S. purpuratus* Stimp. around the mouth region of which there is often a member of this species of ophiuran. Rare and restricted.

OPHIOTHRICIDAE

Plates on upper side of arms small. No oral papillæ. Tooth papillæ. Few buccal papillæ.

Ophiothrix spiculata Le Conte.

Proc. Acad. N. Sc. Phila., 5, p. 318. 1851.

Variable size. Arms five or six times diameter of disc. Disc covered with thorny spines. No mouth papillæ. One tentacle scale. Seven long arm spines. Color greenish brown, red or yellowish. Arms with orange bands. Mouth usually whitish. Some have red discs. Color variation in this species is extraordinary; apparently there is no uniformity.

In *Macrocystis* holdfasts; in rocky tide-pools with *Fucus*; in mussel-beds with *Mytilus*, *Lepas* and *Mitella*. Young also found in calcareous sponge masses, and

among red algæ in rock tidepools. Very common; the most abundant species found at Laguna Beach.

ASTEROPHYTIDAE

Teeth and mouth and teeth papillæ spiniform, indistinguishable. Arms repeatedly divided.

Gorgoncephalus eucnemis M. & T.

Syst. der Aster. Braunschwig. 1842.

A specimen of this species was obtained several years ago, on a line about 160 faths. some distance from the Laguna shoreline. It measures 130 mm. across the disc.

(Contribution from the Laguna Marine Laboratory of Pomona College.)

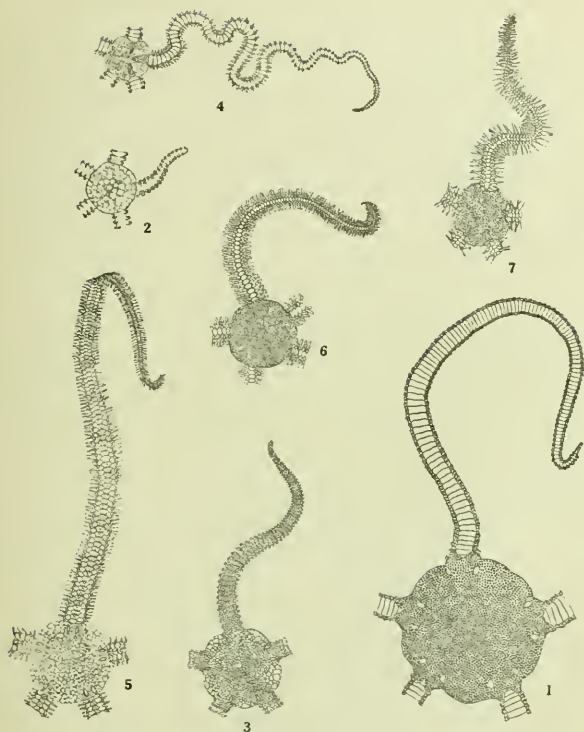


Fig. 1. *Ophioderma panamensis* Lütkin.

Fig. 2. *Ophiocryptus maculosus* Clark.

Fig. 3. *Ophioplocus esmarki* Lyman.

Fig. 4. *Amphiodia barbarae* Lyman.

Fig. 5. *Ophionercis annulata* Le Conte.

Fig. 6. *Ophiopteris papillosa* Lyman.

Fig. 7. *Ophiothrix spiculata* Le Conte.

(All figures are X2, and of the dorsal surface.)

A List of California Arachnida

This list is compiled from already published but scattered papers. Many of these are local records of specimens and new species collected by many students through a number of years and determined for us for the most part by Banks and Chamberlin. As numerous earlier papers in this Journal have taken up the distribution of local forms only a hint of this will be given. There are included in this list records other than local. If the distribution is general some indication is given. A few hints as to characteristic features are given when possible. The family characteristics are compiled by the aid of the works of Banks, Ewing, Comstock and several others. In order to save space the literature references are given in abbreviated form at the end of each section, especially as there are a number of papers and lists already published which give this material in great detail.

I. PSEUDOSCORPIONIDA

M. Moles and W. Moore

CHELIFERIDAE. Evidences of segmentation of thorax in some species. Serrula attached all its length to finger of chelicera. Spinneret long and slender. Flagellum absent. Tarsi of legs one-jointed. Tarsal claws short and thick, split on some of the feet.

Chelifer cancroides Linn. about buildings, oak, sycamore trees, Claremont, mts.

C. fuscipes Bks. Calif.

C. scabrisculus Simon. N. Calif. to Claremont.

Chelanops oblongus Say. Palm springs, Brown's flats.

C. validus Bks. From Lake Tahoe.

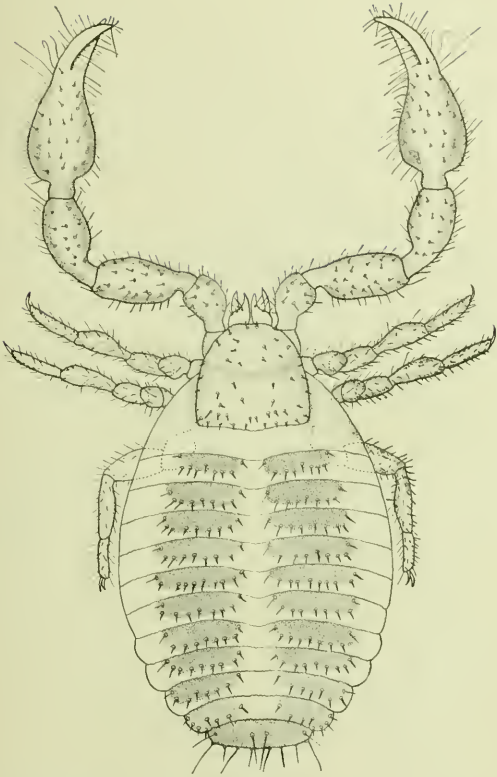


C. pallipes Bks., under stones Claremont, Los Angeles.

C. dorsalis Bks., Lake Tahoe and San Francisco.

C. acuminatus Sim. Maraposa, Claremont, Laguna Beach.

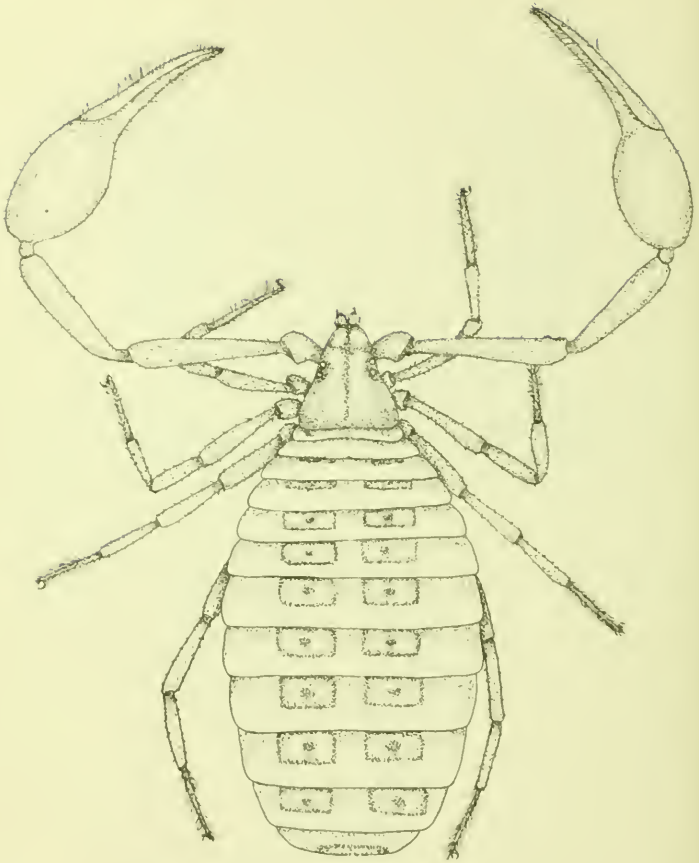
C. lagunae Moles, Two eye spots. Claremont.



C. paludis Moles, Claremont.

C. serratus Moles, No eye spots. Clavate hairs saw-like edge.

Atemnus hirsutus Bks. Laguna Beach near ocean.



Garypus californicus Bks. Under stones Laguna Beach. Also Palo Alto and San Nicolas Island.

Pseudogrypus bicornis Bks. Shasta Springs.

IDEONSTIDÆ. Spinneret long. Serrula attached only at base. Carapace not divided.

Ideobisium magnum Bks. Mt. Shasta. Four eyes.

I. threventi Simon, Four eyes. San Francisco to Claremont.

Ideroncus obscurus Bks. Lake Tahoe and Claremont.

OBISIIDAE. Spinneret small knob. Serrula attached only at base. Carapace not divided.

Obisium macilentum Simon, Claremont-Mt. Shasta.

Blothrus californicus Bks., S. Calif.

B. magnus Ewing. Shasta Springs.

Linn Syst. Nat. ed. 12, 1767. Ann. Ent. Soc. Fr. 1878. Jour. N. Y. Ent. Soc. 1895. Jour. Ent. Zool. June 1914. Jour. Ent. Zool. Dec. 1911, V. 3, p. 633, 1914, 6, p. 818, p. 6, No. 4, p. 87, V. 9, 1917, p. 26, V. Canad. Ent. 1893, p. 67, also 1891, p. 165.



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IV. Coelenterata

HYDROZOA POLYPS. The structure of fresh water *Hydra* has been studied with reference to the nervous system for some time. One of the earlier papers was by Korotneff, '76, who recognized nerve cells. Later work was by T. J. Parker, '80, Rouget, '81, and Schneider, '90. This last author determined a network of ganglion cells to be present. Zoja, '90-'92, finds structures in *Hydra* which he believes are nervous elements because they take special stains and according to him have connections with the epithelial muscle cells and with nematocysts. These cells are similar to the ganglion cells described and figured by Schneider.

Citron, '02, in *Syncoryne* a compound hydroid, finds spindle-shaped sense cells especially in the end knobs of the tentacles. Ganglion cells with three or four processes are found in various parts of the body while bipolar ganglion cells are found in the coenosarc.

Wolff, '03, determined that hydroid polyps have a nervous system, partly of sense cells, partly of ganglion cells. The processes of the latter are more or less joined. The sense cells are primitive intra-epithelial. There is quite a complex network of fibers and cells on the body and tentacles, quite a concentration also on the manubrium. Long strands of the plexus run the whole length of the polyp. There is a less abundant entodermal plexus.

Hadzi in '09, used the isolation method with *Hydra*, also sectioning methods. He found a plexus of nerve cells all over the surface of the body and tentacles; these were chiefly triangular shaped cells. He distinguishes bipolar and tripolar cells as well as some multipolar forms; the first are sense cells. He shows anastomoses at various places. The greater part of the system is an ectodermic network. He says that it is not appropriate to speak of neurones, for the cells are directly connected by protoplasmic processes, and *Hydra* is too far from the type in reference to which the neurone concept was established.

The palm hydroid *Corymorpha*, which is more favorable than *Hydra* for experimentation, has been studied by Torrey '04, Parker, '17, and others.

The reaction systems of coelenterates are cilia, nettle cells, mucous glands and muscles. In this genus, mucous glands and cilia are not important. Nettle cells are apparently independent of nervous control, a condition not true of *Hydra* if we accept the work of several investigators.

There are six sets of muscles in *Corymorpha*; two of these are entodermic, the circular muscle of the stalk and the circular muscle of the proboscis. When anesthetics which control nervous tissues are used, these two muscles remain capable of acting. This probably shows that these muscles are not under control of the nervous

system. The four other muscles, the longitudinal muscles of the stalk, proboscis and the two sets of the tentacles, are quicker in their action and are controlled by anesthetics. These are probably supplied by sense cells and the nerve-net.

Stimuli applied to any part of the normal animal may be transmitted to distant parts; strong stimuli are transmitted to more distant parts than weak ones. The nervous transmission is probably limited to the ectoderm. Although the nervous system is very primitive, reactions much like a true reflex occur, as Parker has pointed out. When a proximal tentacle is strongly stimulated adjacent tentacles respond and the proboscis may turn to the stimulated point.

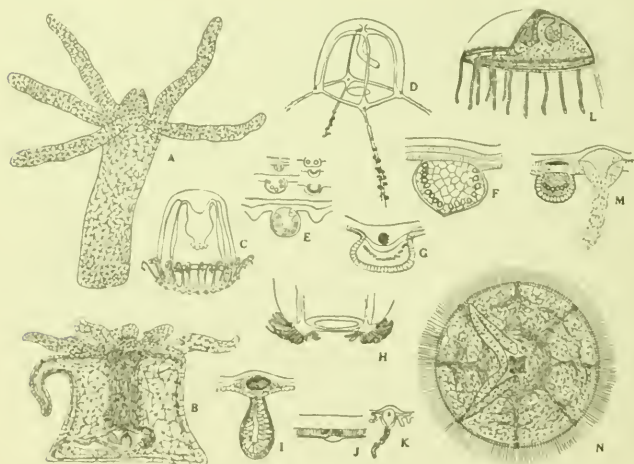


Fig. 4. A. General plan of the nervous system in *Hydra*. B. Nervous system of *Actinia*. Diagrammatic. C, D. Hydroid jellyfish showing position of eye spots. Mayer. E, F. Otocysts of hydroid jellyfish, Mayer. G. Otocyst and eye spot, Mayer. H. Hydroid medusa with eye spots at base of tentacles. I. Tentaculocyst, Mayer. J. Eye spot with biconvex lens, Mayer. K. Tentacle and eye spot, Mayer. L. Diagram of the nervous system of a hydroid jellyfish. Wall of the bell cut away on one side showing section of manubrium and gonad. M. Tentaculocyst and eye spot, Mayer. N. General plan of the nervous system of a scyphozoan, Diagrammatic.

Many parts of the polyp are quite independent of the rest of the body, as may be seen when the hydranth has been removed; the stalk will shorten and even localize a stimulus applied to one side. The hydranth is not necessary for coördinated response. Neither

is the stalk necessary for reflex movements of the tentacles and the proboscis.

The neuro-muscular organization of *Corymorpha* is diffuse and in no sense centralized.

HYDROID MEDUSAE. Although the nervous system of medusae is of the diffuse type, there are concentrations of the network at certain places. In *Gonionemus* there is a double ring of nerve cells and fibers about the margin of the bell. Hyde, '02, mentions a third ill-defined ring; this might be considered to be a part of the diffuse network or plexus which is found over the surface of the sub-umbrella. In addition to the two main marginal bands, there are concentrations of nerve cells and fibers following the four radii of the bell, and the manubrium has some concentration of nerve cells and fibers.

Although the nerve ring is usually double, sometimes it is not divided. The nerve tissue is between the ectoderm and the muscular tissue. In some forms the peripheral system is but poorly developed with only a few nerve cells scattered beneath the surface.

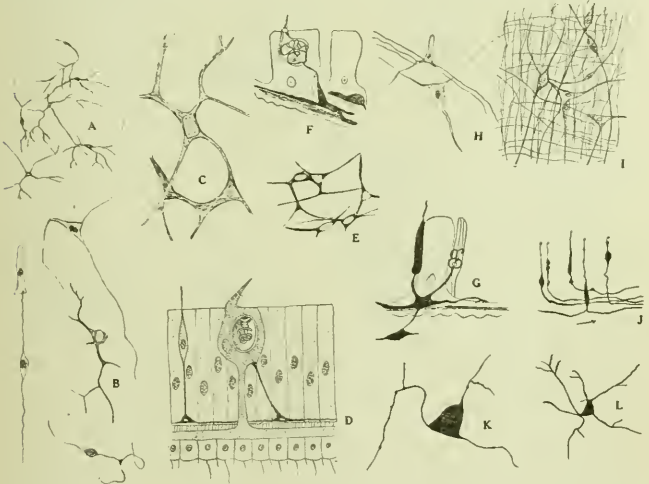


Fig. 5. Nerve cells from various coelenterates from a number of sources. A. Nerve cells from *Hydra*, Schneider. B. Nerve cells and sense cells from jellyfish from Kasseanow. C, E. Nerve plexus from Siphonophora, Schneider. D. Sense cells and nerve cell in *Hydra*. F, G. Nerve cells and fibers in the epithelium of *Hydra*, Wolff. H, I. Nerve cells from actinian, Hertwig. J. Nerve cells from *Cerianthus*, Grosley. K, L. Nerve cells from actinian, Havert.

In *Lizzia*, the Hertwig brothers, '78, found the tentacles grouped, and at the base of these the nerve cord is swollen, due to a concentration of ganglion cells. The suggestion has been made that the two nerve rings have different functions; the upper one connected with the sense organs, the lower being near the muscles gives nerves to them.

Loeb found that if the bell without the nerve ring be placed in five-eighths per cent NaCl or five-eighths per cent NaBr, it goes on beating rhythmically, but small quantities of CaCl₂ or KCl or both added caused the bell to stop contracting. The bell would beat in sea water if not for Ca or K, and possibly some other ions.

When two specimens of medusae are grafted together after the nerve rings are removed, the two portions contract as one and not from two centers of contraction.

Krasinska, '14, in *Cornarina* finds large and small ganglion cells and two kinds of sensory cells. The ganglion cells are mostly multipolar and in a sub-epithelial region nerve elements are also found in the tentacles; large ganglion cells are found in the sub-umbrella and small in the tentacles. The velum is enervated by fibers from the inner nerve ring. She does not decide whether there is a true nerve network because she found but few cases of anastomosis. The large ganglion cells of the sub-epithelial plexus are considered to be motor, also the smaller ganglion cells of the tentacles.

In a hydroid medusa, *Tiaropsis*, Romanes found that the manubrium reaches over to a spot stimulated by touch. Romanes found that this movement continued after the margin with the nerve ring was removed.

Loeb explains the coördinating movements of medusae by simple irritability and conductivity without attributing other special functions to the ganglion cells except those which occur in all conducting protoplasm.

Yerkes, '02, determined that the medusa *Gonionemus* has a delicate chemical sense. All portions of the body except the velum and exumbrella are sensitive to chemical and mechanical stimuli. The tentacles are especially sensitive to photic stimuli. The intensity of the stimulus determines the quickness, duration and extent of a reaction. Stimuli which affect symmetrical points of the body unequally have a directive influence upon the movements. Yerkes concludes that the reactions of special parts of *Gonionemus* are not dependent for their execution upon the functional activity of the central nervous system. Irritability is a property of all parts of the animal except the jelly of the bell and the exumbrella surface, but it differs widely in different regions.

As Loeb suggests spontaneity is not dependent upon the central nervous system but upon a high degree of irritability of certain parts of the margin of the bell. Those specimens with the marginal

ring removed do not show spontaneous movements because insensitive to other than strong stimuli.

Coördination is not dependent upon the function of any nerve center, but upon the rapid transmission of an impulse.

Krasinska finds fibrillae within the ganglion cells of hydroid medusae by means of the iron-hematoxylin method.

In *Polyorchis*, Little 1914, there are two nerve rings, the lower being the larger. All the cells are bipolar. Connections between nerve cells and eye were not determined.

Work by Romanes '98 shows nervous connection between the tentacles and also the manubrium.

The sense organs of medusae, marginal otcocysts and eye spots

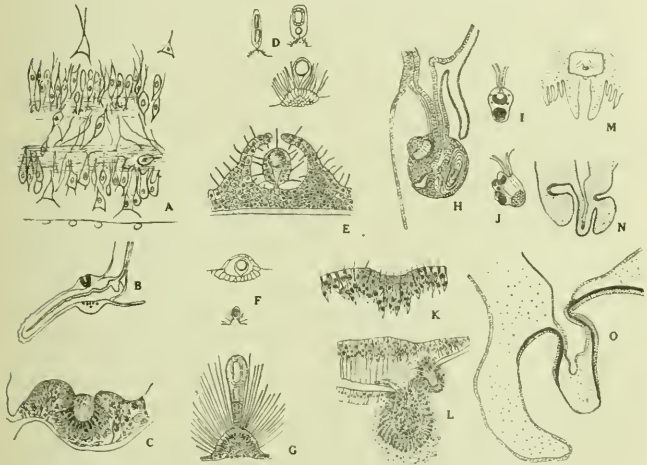


Fig. 6. A. Nerve cells from nerve rings of *Gonionemus*, Hyde. B. Eye spot above lithocyst below tentacle base, medusa. C. Eye spot at base of a tentacle of a hydroid jellyfish, Little. D. Tentaculocysts hydroid medusa, Mayer. E. Tentaculocyst hydroid medusa, Haeckel. F. Tentaculocysts from *Trachimedusae*, Mayer. G. Tentaculocyst hydroid medusa, Haeckel. H. Section through sense organs, eye spots and otolith of scyphozoan jellyfish. I. and J. Front and side views of scyphozoan jellyfish sense organ. K. Simple eye of medusa *Schewai-koff*. L. Section through more complex eyes of *Aurelia*. M. Marginal notch and tentacle of *Aurelia* from above. Eimer. N. Section through marginal tentaculocyst of scyphozoan showing sense areas, dark. O. Section through tentaculocyst scyphozoan, Hesse.

E., from Dahlgren and Kepner's Histology. G., M. and N., from Parker and Haswell Zoology, permission of Macmillan Co.

are often found, but the two kinds are not usually in the same animal.

In *Lizzia*, the eye spots are found on the under side of the tentacle, but in this form the tentacle is held up and its lower side turned toward the light.

In *Polyorchis*, Little '14, the eye spot is on the outer surface at the base of each tentacle. In other naked-eye medusae, similar conditions are found; the eyes may be arranged about the margin as in this form, or in groups to correspond with the groups of tentacles.

In genus *Triopsis*, there are eight marginal sense organs consisting of an entodermal ocellus and an open fold of velum which contains concretions. In *Phopalouema* the lithocysts are inclosed.

In the Narcomedusae there are marginal sensory clubs containing concretions of entodermal origin. Romanes, '98, found that if the bell of a hydroid medusa was removed the contractions of the bell cease, but the margin which contains the nerve ring continues to contract as before the injury. Any injury of the umbrella causes no change in the rhythm so long as the nerve ring is intact. The conclusion from this was that the nerve ring is a coördinating center and one needful for rhythmical contractions.

In many medusae, otocysts or sensory clubs probably function as static organs. In Anthomedusae there are no otocysts, but many have ectodermal ocelli on the bases of the tentacles. Romanes found that these had certain visual functions. Medusae with them were strongly attracted to light between the red and violet spectrum.

In some forms like *Bougainvillia*, the tentacles are grouped and to correspond to each tentacle at its base is an ocellus or pigment spot.

In the Lentomedusae there may be marginal sensory clubs and there may be lithocysts of ectodermic origin. In some forms such as *Laodicea* there may be marginal sense clubs with no concretions within and ectodermal ocelli at the bases of the tentacles.

In *Orchistoma pileus* Larson, there are four hundred dark brown entodermal ocelli on the circular canal; each is provided with an ectodermal lens.

SCYPHOZOANS. The marginal sense organs of this group are so marked as to be early recognized. Ehrenberg, 1837, was the first to speak of these as organs of sense. The usual type is somewhat as follows. At eight marginal notches we find two small tentacles either side of a shorter hollow tentacle. This tentacle or tentaculocyst contains otoliths and the organ seems to be one of equilibrium. Upon the surface of this tentaculocyst there may be a special pigment spot or ocellus of rather simple structure. In the little flap above and also behind or below the short sensory tentacle there may be special areas of cells which may have some sort of olfactory or

chemical sense. Both Eimer and Romanes published physiological papers in 1877-1878 on work done several years previously which seemed to show that jellyfishes had the power of conducting impulses in a complex manner along their subumbrellar surfaces.

Taschenberg, 1877, was unable to find nervous structures and considered that the muscles responded directly to stimuli without the aid of a nervous system. The Hertwig brothers, 1878, clearly demonstrated the existence of a nervous system in medusae. Schafer, '79, found a network of nerve fibers in the subumbrella lying between the muscular layer and the ectoderm, but did not determine anastomosis. Somewhat later Schlater, 1891, believed he had found the true nervous system in the marginal sense organs, but a clear recognition of nerve cells was again made by Kassianow ten years later. He found a nerve plexus in *Lucernaria* and *Carterocephus*. In the latter, tripolar ganglion cells are also found. He shows sense cells and ganglion cells in direct association with epithelial cells.

Hesse, '95, in *Rhizostoma* shows the structure of marginal sense organs in some detail and gives some indication of the nervous system. Fibers run from the eight marginal sense areas to a more or less circular band which is somewhat poorly defined, and other strands spread out over the subumbrellar muscular bands of the jellyfish. The relation between cells was not clearly shown.

Bethe, '09, was able to prove that the nerve plexus in *Rhizostoma* is a true network.

Romanes and others have shown that the bell of a jellyfish could be cut in a most complex manner without preventing the passage of a stimulus for a contraction wave.

If a single marginal body is stimulated, contraction waves start both to the right and to the left of the stimulation until they mingle and disappear.

If the center of the jellyfish is cut out and the margin deeply notched, the tortuous pathway of tissues thus formed is capable of carrying a contraction wave. If a jellyfish with one marginal sense organ is cut in a spiral strip, a wave of contraction may be started at the margin which will run the whole length of the strip.

A jellyfish cut so as to make two concentric rings with only two slight connections between will carry the impulse from the outer to the inner portion by this narrow bridge. If the jellyfish is cut so as to form a long circular stretch, a wave may course for a long period round and round the bell. Such a "trapped" wave has been known to go for eleven days with no great decline in rate; or at the rate at which it was traveling, it would have covered a distance of four hundred and fifty-seven miles in eleven days, Parker, 1919.

The removal of the marginal bodies of a medusa causes the movements to cease for a time, but it may be made to contract by electrical or chemical stimulus. Experiments by Bethe seem to show

that although the muscle of the jellyfish is capable of direct stimulation, it is not so sensitive as the nerve-net. Parker summarizes the susceptibility to stimulation as follows: 1. Marginal bodies most sensitive. 2. Nerve-net. 3. Muscles directly stimulated least sensitive.

Mayer, 1917, concludes from his experiments with *Cassiopea*, that nerve conduction is due to a chemical reaction involving the cations of sodium, calcium and potassium. The probable high temperature coefficient of ionization of this proteid may account in some measure for the high tension coefficient of the rate of nerve conduction, which he finds is two and five-tenths as great as that of the electrical conductivity of the seawater surrounding the nerve. His observations do not support the "local action" theory. The rate of nerve conduction is practically identical whether sea water is diluted with 0.415 molecular mercuric chloride or with distilled water.

Corry, 1917, working with the same species found that regeneration takes place more rapidly on the half of the jellyfish in which the sense organs were not removed. When sense organs are removed and one half stimulated by electricity and the other insulated half not stimulated, regeneration is more rapid on the activated part. The experiments show that the rate of regeneration is but one expression of the general metabolic activity of the animal and as such is subject to the influence of the nerve centers as are many other functional activities. It is concluded as a result of experiments that some chemical interchange between sense organs and the surrounding tissue is necessary in order that the activity of these structures shall be maintained at the highest state of efficiency.

Some sort of trophic influence is exerted in general metabolic activities by the sense-organs. The structure of the nervous system of this form makes it impossible to prove the existence of tropic-nerve fibers as distinct from those of sensory or motor functions.

In *Pelagia*, Krasinska finds large and small ganglion cells in association with sense cells. The large ganglion cells are considered to have a motor and the smaller ones a sensory function. There are three methods of connecting the nerve plexus with the epithelial surface. (1) Through peripheral processes of the ganglion cells. (2) Through sense cells. (3) Through free nerve endings. No direct proof of the enervation of the muscle fibers was established.

The tentacles have large and small ganglion cells, the cells are deep in the muscular folds but in the outer epithelium is a fine nerve-fibrillar area. Similar fiber masses are found in other parts of the body and the nervous system; these may correspond to a "neuropile." Fibrillae were found especially in the branches of the ganglion cells.

ACTINIANS. The reactions of the actinians have attracted at-

tention from quite early times; Milne-Edwards in his natural history of corals in 1857 wrote:

"They enjoy a highly developed sensibility, not only do they contract forcibly on the slightest touch, but they are also not insensible to the influence of light. But no nervous system or organs of sense are to be discovered in them." In these early times there were, however, some vague suggestions of ganglia and nerve chords in *Actinia*, but no confidence was placed in them. Huxley, in his elements of comparative anatomy of 1864 says: "The nervous system has at present not been determined in them." Alexander Agassiz, in his seaside studies of 1871 says: "Only a few pigment cells found at the tentacles are sense organs."

Schneider and Ritteken, 1871, state that the chromatophores are organs of sense, compound eyes.

J. D. Dana in his *Corals and Coral Islands*, states that "they sometimes possess rudimentary eyes."

Duncan, 1874, describes in some detail the structure of the "eyes" of actinians. He also recognizes a plexus or network of nerve fibers and cells under the epidermis, and remarks that the diffuse nature of the nervous system is what might have been anticipated.

The first rather complete account of the nervous system was by the Hertwig brothers in 1879-80. They recognized sensory cells in the epithelial layers and under the epithelium and next to the muscular layers of both ectoderm and entoderm a layer of nerve fibers and cells. The sensory cells when stimulated carry impulses to the nerve cell layer and this in turn to the muscles beneath them. Nerve impulses from the ectoderm to the entodermal muscles were supposed by them to pass over the exterior to the oesophagus and from its inner end to the entodermal musculature. They considered the body of the sea-anemone to be rather uniformly supplied with nervous tissue except at the oral disc where in the ectoderm the cells were concentrated in a sort of center. Wolff, 1904, and Grosley, 1909, in the main accepted Hertwigs' suggestions but they placed the concentration of the nerve fibers in the wall of the oesophagus and not in the oral disc.

Kassianow, 1908, in *Alcyonaria*, believed the disc to be the center of an individual member of the colony and Liedermeyer, 1914, although his observations were of sections alone, was of a similar opinion from his study of one of the *Pennatulacea*.

Havert, 1901, on a sea-anemone by means of the Golgi method, maintained a diffuse nervous system for actinians. This author also believed that the ganglion cells, so-called by the Hertwigs, were really motor cells which receive impulses from sensory cells and then transmit them to muscles, a condition more like that of the central nervous system of forms with a reflex arc. This author also

showed a direct connection between ectoderm and entoderm, a conclusion which Parker, 1917, and Parker and Titus, 1916, have shown on both anatomical and physiological evidence.

Von Heider, 1877, was of the opinion that the mesenteries of some actinians might contain nervous elements. Wolff, 1904, and Kassianow, 1908, were of the opposite opinion but a number of investigators seem to have shown that Von Heider's opinion is the right one, among them Hickson, 1895, Ashworth, 1899, Kükenthal and Proch, 1911, and Liedermeyer, 1914.

In recent years Parker has given this group considerable attention and some of his conclusions will be employed in the following discussion. There is also a paper on the histology of actinians by Sanchez, 1918, but in this the nervous system is not considered very extensively.

The effector systems of sea-anemone are mucous glands, ciliated epithelium and muscles. Although nematocysts are considered by some to be under control of the nervous system, there is good evidence that they are independent of it. The only system under the control of the nervous system is the muscular. By means of experiments it was learned that the bases of the anemones were especially sensitive, but nervous transmission may be accomplished from almost any portion of the ectoderm to its longitudinal mesenteric muscles. By several experiments it was proved that the transmission might be by means of almost any narrow bridge of tissue, proving quite conclusively that the transmission is by a nerve-net.

Many muscles responded at some distance from the point stimulated and in some cases muscles were capable of responding directly to a stimulus; whether these muscles were also under the control of the nervous system at other times was not clearly established in every case. In the acontia, however, there seemed to be no intermediation of nerve impulses in the response to stimuli. Connections from ectoderm to entoderm was proved in many cases. In connecting the ectodermic and entodermic system the lips and oesophagus seemed not as important organs as other parts of the body.

Although the system of the actinians is diffuse there is some degree of specialization. If the tentacles are stimulated by a nutrient fluid the oesophagus gapes by contraction of the transverse mesenteric muscles, while weak acid causes a retraction of the oral disc by means of a contraction of the longitudinal mesenteric muscles. The two kinds of response suggest independent receptors and relatively independent transmission tracts.

In the tentacles the ectodermal surface is more receptive than the entodermal; if there is a nervous structure in the latter it is probably very simple. The tentacles are complete neuro-muscular organs and may react quite independently of the polyp, as shown when severed from the body.

Parker has measured the rate of transmission of the nerve impulse in sea-anemones at 21° centigrade. It was found to be from 121-146 mm. a second.

Kassianow, Parker and others have studied the nervous system and reactions of colonial forms. There seems to be little evidence of any nervous coördination in colonial polyps, each polyp in *Renilla* for instance when stimulated by contact seems to react independently of the rest. Although the common flesh which supports them may bring about like changes in several or all of the members of the colony, the zoöids are not centers from which impulses pass to other parts.

The peduncle and rachis are probably permeated by a nerve-net which extends from the zoöids of the colony.

CTENOPHORA. The first observations on the nervous system of this group were by Pschschiltz, 1829, and later by Mertens, 1833. One of the first complete summaries of the general structure of the

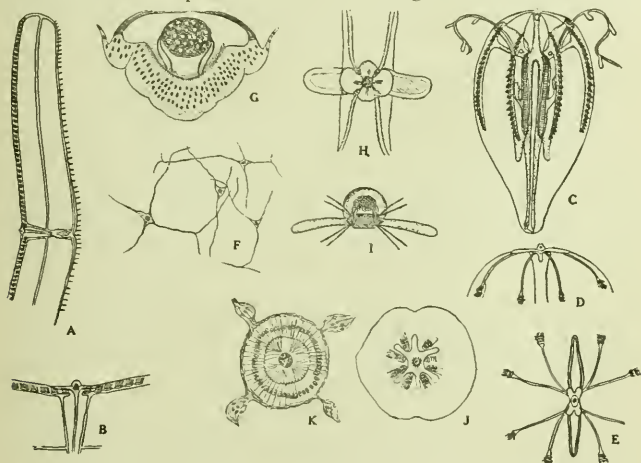


Fig. 7. Two-thirds of an elongate ctenophore, Mayer. B. Enlarged portion of sense organ of elongate ctenophore. C. Diagram of a ctenophore, Mayer. D. Sense organ of ctenophore from side showing connections with the eight ciliary glands. E. Same as D from above. F. Nerve plexus of a ctenophore, Hertwig. G. Apical sense organ of a ctenophore after Hertwig. H. Diagram of a ctenophore, Hertwig. H. and I. View of apical sense organ of a ctenophore showing its relation to the ciliary bands. H from the side, I from above. J. *Coenoplana* from above showing apical sense organ, Korotneff. K. *Coenoplana* sense organ in section with associated ganglia, Abbott.

I., J., from Parker and Haswell's Zoology, permission of Macmillan Co.

nervous system was by Hertwig, 1880. A subepithelial nerve plexus with the bipolar and multipolar cells has been described and figured. Bethe, '95, also describes and figures a network of nerve cells and fibers in ctenophores.

The characteristic aboral sense organ was first described by Edwards, 1841. At a later time Chun, 1878, describes and figures it in detail showing the little otocyst with its group of calcium crystals supported on four bands of fused cilia like a little table, with each tip of the leg coming into relation with two of the eight ciliary bands.

This peculiar balancing organ has been considered in a way to represent a central nervous system because of its reaction to the ciliary bands. These bands seem not to be under the control of the nerve cells and fibers, but some are of this opinion. The nervous system then would not relate to the cilia, but in some way there is a coördination of movement in the eight ciliary bands. That this is not as simple as might at first seem is shown by the fact that the effective stroke is in the opposite direction from the wave of ciliary action, so that the simple explanation of the movement of one cilium affecting the next, like a row of tenpins, does not hold.

Bauer, 1910, found by gently touching the mouth region of a ctenophore, that it stopped its cilia. If vigorously stimulated its plates vibrate more actively for a short time. If the aboral sense organ be removed the same reactions apply as before. He concludes from this that the reactions cannot be ascribed to the sense body but must depend upon the action of the diffuse nervous system which although chiefly concerned with the muscles of the ctenophore seems also to have an influence on the rows of swimming plates.

Göthlin in a recent paper, 1920, on the study of ciliary movements finds that the primary inhibition of the ciliary movement is probably due to cilio-inhibitory nerves. Receptors at the surface of the body transfer their impulses to the nerve-net. These in turn transmit them to the end apparatuses which inhibit the vibrations of the swimming plates, probably blocking the neuroid conduction between them. There is an intimate connection between primary and secondary inhibitory mechanisms. Both probably use the same receptors, but the primary mechanism functions on impulses of weaker intensity.

Abbott, 1904, who has studied the interesting worm-like *Coeloplana* has found a rudimentary nervous system with four ganglia symmetrically disposed about the otolithic capsule. Just outside the otolithic capsule in the angles formed by the intersecting tentacular and sagittal planes are four large nerve ganglia that send off fibers to form a sort of diffuse peripheral system and supply fibers that cover part of the capsule as an enveloping sheath. Each gang-

lion is opposite the point of insertion of the cilia which support the otolith. The cells of the nerve tracts and ganglia are large, triangular and stain deeply with methylene blue.

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Journal of Entomology and Zoology

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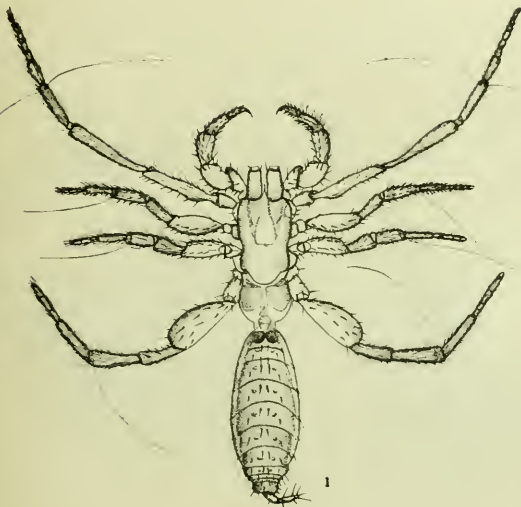
A List of California Arachnida

II. PEDIPALPIDA OR

WHIP-SCORPIONS

M. Moles

SCHIZONATIDAE. Eyes wanting, caudal appendage short, unsegmented or knob-like segment at end.



Trithyreus pentapeltis Cook. Found rather commonly about Claremont, Laguna Beach and farther south.

TARANTULIDAE. The tailless whip-scorpions. Eight eyes.

Acanthophrynus coronatus. May be nearly two inches long. Calif. possibly some specimens in the Pomona College collection may have some from the southern part of the state but no clear record.

Proc. Ent. Soc. V. 4, p. 249. Jour. Ent. Zool. V. 9, 1917, p. 1.

A List of California Archnida

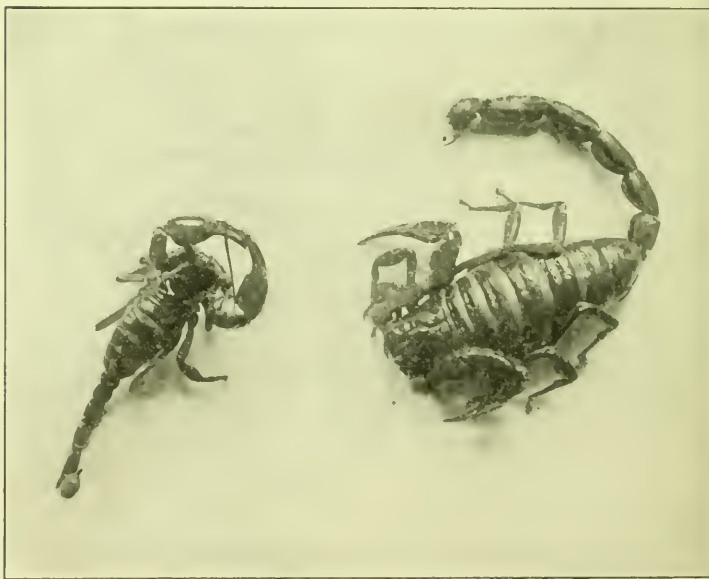
A LIST OF CALIFORNIA ARACHNIDA

III. THE SCORPIONIDA

Fred A. Cox

BUTHIDAE. Triangular sternum. One or two spurs on each side at base of last pair of legs. Three to five lateral eyes on each side. Hand of chelae rounded, fingers long. Usually a spine under the sting.

Uroplectes mexicanus. No spine under sting. Teeth on finger of palpus in many oblique rows. Texas and Calif.



Isometrus maculatus Linne. Santa Barbara and Catalina Islands. Slender long tail.

Tityus tenuimanus Bks. Bue a Vista.

Centruus californicus Wood. Lake Tule and Lake Co., Calif.

C. exilicaudus Wood. Lower Calif. and near San Diego.

SCORPIONIDAE. Only one spur at base of last tarsal segment of last pair of legs.

Diplocentrus whitei. Texas and Calif. Twelve to eighteen teeth on comb.

CHACTIDAE. Only two lateral eyes on each side.

Broteas alleni Wood, length 1 to 1½ inches.

VEJOVIDAE. One spur each side of the base of the last tarsal segment of last pair of legs. Three lateral eyes on each side. Sternum usually broader than long. No spine under sting.

Uroctonus mordax Trosell. Dark colored, large claws. Common in Central and Northern Calif.

Anuroctonus phaeodactylus Wood. Rather hairy, red-brown. San Diego, Mojave Desert, Claremont. Common species.

Vejois punctipalpi Wood. Red-brown, strongly ridged claw. Death Valley, San Diego Co.

V. hirsuticauda Bks. San Bernardino Co. Red-brown, 15 pectines. Length 1¼ inches.

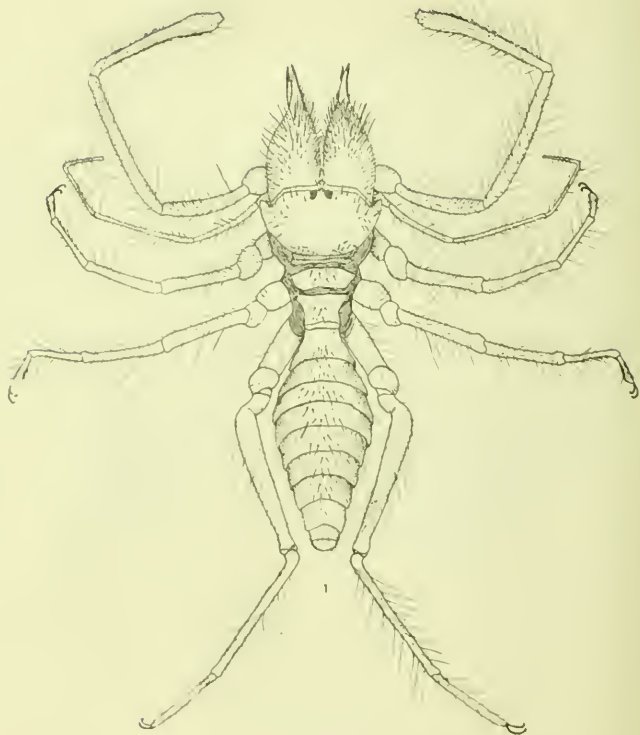
Hadurus hirsutus Wood. Deserts of S. Calif.

C. Jour. Ent. V. 2, 1910, p. 185. Ann. Mag. Nat. Hist. XVII, 1876, p. 11. Jour. Ac. Nat. Sc. Phila. 1863, pp. 387, 369, 372.

A List of California Arachnida

IV. SOLPUGIDA

J. Nesbet



SOLPUGIDAE.

Eremobates formicaria Koch. Large specimen from Brawley. No spines under tibia in either sex.

E. californica Sim. From Laguna Beach and Calif. Movable finger of male constricted from below near apical third.

E. formidabilis Sim. Small spines under side tibia of palpus of male. Calif.

E. putnami. No spines on tibia of palpus of male. Calif.

Hemerotrecha californica Bks. Upper finger of chelicera with no teeth or many small teeth. Pacific Grove to Claremont.

Ammotrecha californica. Lower finger of chelicera fine teeth beyond large teeth at base. Broad dark band on middle of metatarsus of palpus. Calif.

Class des Galeodes 1879, p. 143. Ent. News 1903, p. 79. Jour. Ent. Zool. IX, p. 22. Proc. Acad. Nat. 1883: 3, p. 249.

Notes on Sense Organs in Some Asteroids

ARTHUR S. CAMPBELL

The sense organs of many species of starfish have been well studied during the past fifty years by a number of competent observers. Among the earlier important studies are those of Haeckel, 1860; Wilson, 1862, and Hamann, 1885. Later work, especially the more minute observations are the subjects of study of Cuénot, 1887, and of Pfeffer, 1901.

Materials for this study include most of the common littoral asteroids occurring at Laguna Beach. Representatives of six species, the members of three orders, were examined. All preparations were fixed in HgCl₂ and double stained, first in hematoxylin and then in picro-fuchsin.

Eyes are placed at the terminus of each ray, and just proximal and ventral to the terminal tentacle. In nearly all species they are well protected by a strong circle of heavy spines. They are mostly of a deep red color which is slowly soluble in alcohol.

Viewed more closely the eye-spot appears as a pad in which there are a number of little depressions; these are the ocelli. Each presents a separate structure, the whole eye-spot being merely a composite of many ocelli. The number of ocelli varies greatly.

The histology of the ocelli in these forms has been disputed by several observers. Most of the earlier workers believed that lenses are present. Cuénot, 1887, does not accept this, but Pfeffer, 1901, indicates a lense in *Asteropectin mulleri*. In some of my preparations there is a little indication of an epithelial thickening bridging the eye-cavity, but mostly the eyes show a clear and rather wide, open space freely in communication with the exterior. These preparations indicate somewhat an intermediate condition between the two figures reproduced from Pfeffer.

Cells forming the eye are of two types. The several reproduced from Cuénot's paper, fig. 12, are pigment cells or sensory cells of the retina. They are surrounded and supported by cells of a second type; the so-called supportive cells of Cuénot and others.

The comparative structure of several eye preparations is figured. The supportive cells are well stained with fuchsin.

A sense organ in starfish was seen in *Linckia colombiae* Grev, among my preparations in the course of this investigation. It is probably a tactile organ. It is seen in the ventral portion of the terminal tentacle, near the eye-spot. It consists of a number of papillæ extending over a restricted area of the tentacle. The papillæ are pronounced and have a similar structure to those found in other forms. They follow through a small series of sections rather completely, showing constant form. These may be like the so-called organs of taste described by Eimer, 1880.

(Contribution from the Zoological Laboratory of Pomona College)

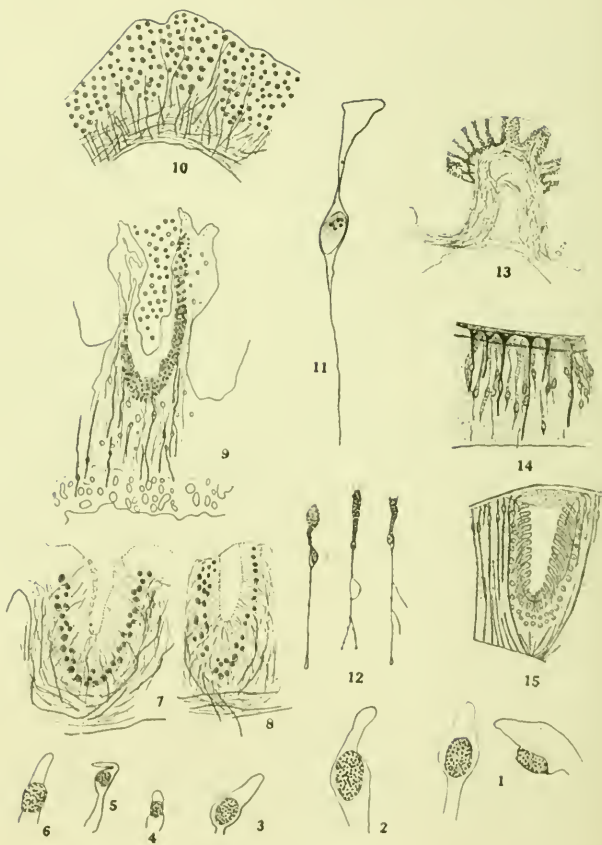
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V. Flatworms

TURBELLARIA. Among the turbellarian flatworms those of the Rhobdocoelida are the simplest. Böhmig, 1890, describes and figures a number of central nervous systems from Alloecoela such as shown in Fig. 8. The ganglia are somewhat concentrated but show right and left halves. Two or four pigment spots imbedded in the brain substance may show but little indication of differentiation into eyes.

Among the Acoela some have simple pigment spots for eyes and some are without them. Statocysts are found in the center of the ganglionic masses in some cases. Very often a well-marked statocyst or otocyst may be seen in the center of the upper portion of the animal, just between the pigment spots when they are present. The brain is not very extensive in Acoela. It is usually recognized as a small mass of cells surrounding the central statocyst. Löhner in *Polychoerus* gives about as complete account of the nervous system as any. There is a central ganglion with a central otocyst. Laterally there are two ganglia of nearly equal size. These ganglia in cross section are nearly central in position while the peripheral nervous system consists of longitudinal strands both dorsal, ventral and lateral in position. Figure 8 shows the plan of the nervous system as a whole.

De Quatrefages, 1884, and Peebles, 1915, and others give some indications of the nervous system and sense organs of these worms, but not much in detail.

Many investigators have dealt with the Rhobdocoela. The brain is a little more complex than that of the other groups mentioned but the whole system is compact and there are few longitudinal cords from the brain region.

Some forms have from two to four simple eyes imbedded in the brain. Sensory pits near the head end are found connected with the brain in some. Ott, '92, describes "dish-shaped" organs near the dorsal surface of the body of *Stenostoma*. In this form the ciliated pits are imbedded in the forward portions of the brain. In other forms, they seem to be entirely separate.

Schneider, '73, finds the lobes of the brain connected by a double commissure which surrounds the vascular system. Hallez, '79, Ott, '92, and others find but a single commissure.

The fibrous portion of the brain or "punkt substance" is composed of a fine network of fibers which some have thought was made up of anastomosing processes, but the evidence is not clear. Nansen, '87, does not believe in an anastomosis.

Some of the figures from the nervous systems of this group show few branches. Probably more branches were present although not recognized in every case by the investigators.

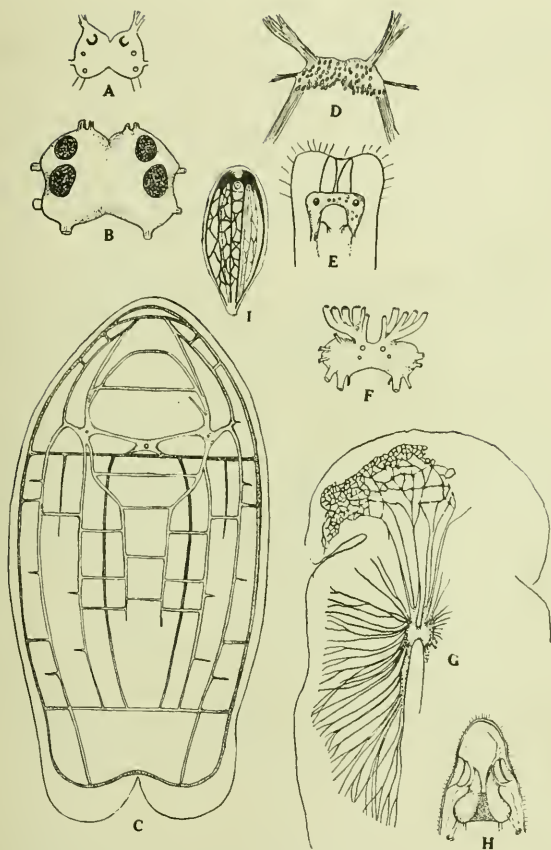


Fig. 8. NERVOUS SYSTEM OF RHABDOCCELIDA. A and B. Brain with one and two pairs of eyes of alloecocoelan flat worms, Böhming. C. Nervous system of an acoelan, *Polychoerus*, Löhner. D to H. Brains of Rhabdocoela. D. *Opistoma*. E. *Prorhynchus*, after Vejdovsky. F. *Gaffilla*, Böhming. G. Rhabdocoela nervous system, Böhming. H. *Stenostoma*, Ott. I. An acoelan showing nervous system after Böhming.

The brain consists of a rather broad flat mass of nerve fibers and cells occupying quite a large part of the forward portion of the head end. Many nerves run out to the surface of the body and two chief longitudinal strands run the length of the body. Usually a number of commissures connects the two parts of the brain as well as the two longitudinal strands. The number of these is somewhat variable in the different species and also in members of the same species. In some forms at least, terminal fibers connect peripheral branches at the margin of the body. Fig. 9, A, D, E. Usually two eyes are found connected with the brain by short nerves, but in some cases at least, such as in *Sorocelis*, as described in Seidl, 1911, there are neurone eyes scattered over the anterior region of the forward end.

Lateral extensions of the head end are often especially sensitive and provided with abundant nerve cells. The eyes, simple or complex have been well described and figured by Hesse, 1896. A sensory cell or cells with expanded ends terminate in a pigment cup which aids in centering the light on the protoplasmic ends of the sense cells. Fig. 9 F-H.

Very little has been done in analyzing the motor and sensory components of the brain and nerves. Branches to the eyes and to the surface of the body, especially the forward end of the body, are undoubtedly sensory in nature. The brain has been divided by some into an anterior and superior sensory region and a posterior and inferior motor portion. Some of the chief works on this group are by Chichkoff, '92; Iijoma, '84; Lang, '81; Woodworth, '91; Wheeler, '94; Vejdosky, '95; Hesse, '97; Micoletzky, 1907; Weiss, 1910; Seidl, 1911.

Rina Monti, 1896, has studied the nerve terminations in the skin of fresh-water planarians.

The Polycladida are usually considered as having a more complex nervous system than the tricladids, but it is more concentrated. As a rule there is a number of simple eyes scattered over the forward end of the body such as shown by De Quatrefages, 1844, although in *Planocera* Lang, '82, shows rather concentrated eye areas. In *Leptoplana*, the eye spots are scattered about in the region of the nervous system, as shown by Schmidt as early as 1862.

Although locomotion in planarian worms may in part be by the surface cilia, the chief activities seem to be by means of muscles of the body under the control of the nervous system. Weak chemical or tactile stimuli cause them to react positively. The resting worm responds less readily than the moving one. Some forms with much more highly organized eyes react less well than others with simpler eye spots. As a rule strength of light is less important in reactions than the number of sensory elements in the eye, or the former

habits and experiences of the animal. Headless forms respond to light but less quickly. As a rule if the head and eyes of a planarian are removed the headless portion reacts as before but much more slowly. In marine flatworms where the ganglia are more concentrated in the head region and where there are fewer ganglion cells along the lateral cords, the activities of the headless worms are much less perfect than in planarian worms of fresh water.

In the flatworms special cells of the ectoderm give rise to the head ganglia. Later stages, or the development of the peripheral system have been but little studied.

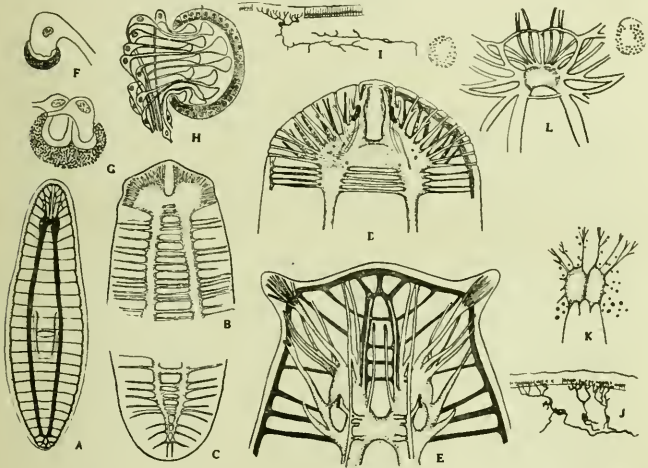


Fig. 9. NERVOUS SYSTEM OF POLYCLAD AND TRICLAD WORMS. A. *Snycoelidium*, Wheeler. B, C. Head and tail ends of *Sorocelis*, Seidl. D. Brain and head end of *Planaria bohmei*, Weiss. E. *Planaria apina*, Micholetzky. F and H. Eyes of Planarians, Hesse. I, J. Nerve endings in skin Planarians after Monti. K. Brain and eyes of *Leptoplana*, Schmidt. L. Nervous system and eyes polycladid, Lang.

Kepner and Rich, 1918, have studied the reactions of the proboscis of flatworms. In accordance with Monti, '97, and Steiner, '98, they found that the ventral nerves are ganglionic and these centers exercise control over the posterior parts of the body. The middle branch from each of these ventral nerve trunks leaves the ganglion that lies nearest the base of the proboscis and from here enters it. When the proboscis is removed from the animal it undergoes autoamputation. Without the control of the adjacent

ganglia the proboscis in this way acts as a reflex organism. The freed proboscis is able to carry out the three usual coördinated muscular movements when the muscles are intact. The free proboscis cannot determine food from other substances. The central nervous system is necessary for this.

The eyes of turbellarians have been extensively studied by Hesse, '96. In tricladids they consist of visual cells and pigment or accessory cells. These last inclose the enlarged ends of the visual cells, the rhabdomes. The number of visual cells or retinulae as well as the accessory or pigment cells differs greatly. Kepner and Taliaferro, '16, found the retinulae to consist of three regions; a lateral nucleus bearing region closely applied to the brain with a nerve fiber extending into it, a middle region lens shaped, homogeneous and highly refractive, and the true rhabdome in the pigment cup. Kepner and Foshee, '17, compare the three regions of the retinula with the rods and cones of vertebrates. The parts show a close analogy if not homology with the myoid, ellipsoid and rhabdome. The retinulae of both flatworms and vertebrates are also of the inverted type. Taliaferro, 1920, has an important paper on the reactions of *Planaria* to light. The species considered was negative to light and turned itself accurately to horizontal rays. In some cases the reactions were direct, they turned away at once without preliminary movements. Specimens with both eyes removed do not react exactly as normal individuals, but they do move in general away from light. The rate of locomotion in these is not appreciably affected, but the removal of the anterior end greatly retards the rate of locomotion. Specimens with one eye removed orient themselves accurately to light when illuminated on the normal side, but do not when stimulated in this way on the blind side.

According to Taliaferro, light must strike a given rhabdome parallel with its longitudinal axis in order to cause stimulation. "Thus, the position of the longitudinal axis of the rhabdome results in a localization of photic stimulation." It is possible, according to this investigator, to explain the localization of photic stimulation in one of two ways. First, the refractive central region of the retinula acts as a sort of lens to concentrate the light on the sensitive rhabdome. Second, by assuming a certain structure of the rhabdome coupled with a shading action of the pigment-cup. Hesse, '97, ascribes the localization of the stimulus entirely to the pigment-cup.

TREMATODA. In monogenetic forms such as *Tristomum* Lang, 1881, or *Epidella*, Heath, 1902, the brain consists of a rather short, semicircular band near the dorsal surface just in front of the pharynx. From it six longitudinal nerves arise, four ventral and two dorsal. These extend the length of the body and end in the posterior sucker. Many small nerves spring from the brain and the six

longitudinal cords. A short distance from the brain the anterior nerves are united into a curved ganglion and from this a number of branches run to the anterior end of the body. On the mid-dorsal line a small median nerve in *Epidella* runs towards the head and towards the sucker, but was not found farther than this.

In the main nerve strands and ganglionic areas bipolar cells are of frequent occurrence and generally one branch from each might be traced close to the surface of the body while the other fiber passes into the brain. In a few cases the fibers pass to the opposite side of the ganglion or brain before they terminate. Cells with three branches in *Epidella* were found with one process to the

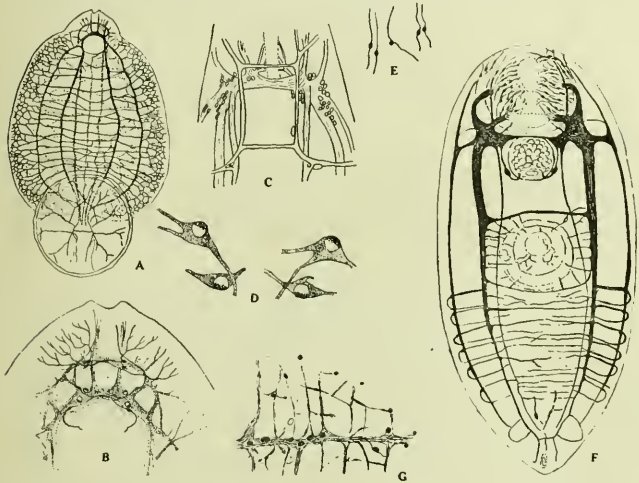


Fig. 10. TREMATODE WORMS. A, B, D, Monogenetic forms. C, E, F, G, Digeneic. A. Nervous system *Tristomum*. B. Head end of *Epidella*, Health. D. Eyes of *Epidella*, Health. C. *Amphistomum*, Loos. E. Sensory cells of trematode, Havest. F. Nervous system of *Cercarioenium*, Bettendorf. G. Nerve plexus *Corcoriaenum*, Bettendorf.

brain, another to the substance of the sucker of the same side, and the other crosses over to the sucker of the opposite side.

In *Epidella*, the large mass of nerve fibers and the more numerous longitudinal bands on the ventral side are explained by the fact that this side rests against the host.

There are four eyes in *Epidella*. In other forms they seem not

always as well developed and may not always be functional. In this form the eyes appear as four small pigment spots partly imbedded in the dorsal surface of the brain. In this and in *Tristomum*, each eye-spot consists of an almost spherical, highly refractive transparent body which in many cases contains one or two small vacuoles, but a nucleus was not seen. The lens is partly covered by a cup of dark brown pigment granules. These parts are imbedded in a rather large ganglion cell. Two or three fibers arise from each ganglion cell and extend some distance into the brain. A series of delicate muscles are near the eyes and their contractions bring about rotations of the eyes. One pair of eyes has been found to move simultaneously with the other, although this does not always take place. If the animals are vigorous the movements of the eyes may take place with the rapidity of a heart beat.

The eyes are situated on the dorsal side of the brain. The tissue between them and the ventral side is clear and light passing under the host must strike the lens and affect the retina as the pigment is placed in the most favorable position in the anterior side of the lens.

In some digenetic trematodes the nervous system has a rather complicated system of branching as shown in *Amphistomum* by Loss, 1892. Nerve tracts are clearly defined and nerve cells, although chiefly centered in the broad brain, are also found out along the peripheral nerves.

Faust, 1918, has studied the eyes in digenetic trematodes. In twenty-eight species, seven possess pigmented eyes and four non-pigmented ones. Binocular species usually have the eye spots in direct connection with the posterior dorsal nerve trunks. In one at least connections were with the anterior dorsal rami. The central eye of tricoelate species is fused to the anterior dorsal nerve trunk by a blunt fiber from below. The eye spots consist of a cluster of rather dark-brown granules forming a deep cup. Within the cup is a spherical body barely touching the pigment granules. This is the enlarged nerve ending with a nucleus within.

The development of the eyes in *Cercaria gigas* is as follows:

A branch of the posterior dorsal nerve with a single nucleus pushes out from the nerve center to the dorsal margin of the embryo. As it reaches a position near the surface, the ectodermal layer of the embryo pushes inwards just posterior to the nerve, so that a pocket is formed with the opening opposed to the nerve cell. The end of the nerve fiber enlarges and twists about the inner wall of the pocket so that the end with the nucleus comes to lie within the cup. At first the ectodermal cells are evident, but later they disappear. Pigment granules are not present until the nerve ending comes to occupy its position within the pocket. Golden-brown pigment granules come to be formed between the nerve endings and the

ectodermal cup. The cell within the cup enlarges and becomes the lens. The lens is in this way derived from the nerve center.

In *Cercariaenum* Bettendorf, 1897, shows six longitudinal strands from the brain, with many branches to the pharynx and the suckers. A complex nerve plexus of nerve fibers and nerve cells is found over much of the body. Especially are bipolar sense cells found in the pharynx. Similar bipolar sense cells are demonstrated by Havet, 1900, by the Golgi method.

CESTODA. The scolex contains the greatest concentration of the nervous system although in *Gryocotyle* there is fully as great a

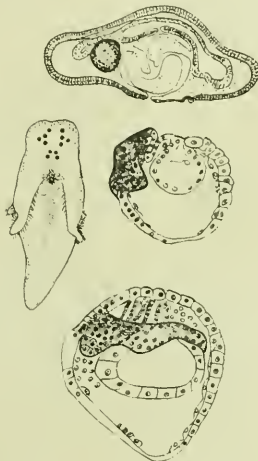


Fig. 12. The sketch at the top is from a section across a young flatworm showing the brain as a dark mass in the left side. The figure at the left below is from a larval flatworm showing the position of twelve simple eyes. The middle and lower left hand figures are from embryonic stages of a nemertean worm showing the developing nervous system on the left and shown darker in the figures. Salensky.

mass of central nervous system in the caudal end of the animal. The suckers or other appendages of the scolex region are supplied with special branches. In some forms there is a definite ring of fibers. In all two larger and usually four smaller longitudinal strands run the length of the animal.

Blanchard, 1847, dissected the nervous system in *Ligula* where he found a mass of nervous tissue in the scolex with strands run-

ning through the body, especially two thick ones. Moniez, 1881, found the commissures in the forward end of the body.

Lang, 1879-82, figures and describes the nervous system of a member of the Cestoda where he finds a concentration in the scolex region and nerves running from this center to the appendages in this region when present and also long nerves which run the length of the body.

Roboz, 1882, shows the central ganglion and an extensive nerve network in cestodes. Some authors claim to have seen ganglion cells along the nerve strands and in fact Kahne considers the chief longitudinal strands as central organs.

Haman, 1885, also describes the long nerve fibers as having ganglion cells on them.

Niemeic, 1886, in *Ligula* shows a central ganglionic mass with two thick strands leading from it and four or more smaller ones, some of which branch again. Blanchard found similar conditions.

In *Schlistocephalus*, Moniez gives a brief description of the nervous system also Niemeic, 1886.

In *Bothrioccephalus*, Niemeic gives some indications of commissures in the scolex region.

In *Taenia*, Blanchard gives some indication and Moniez distinguishes a nerve ring in the tip of the scolex. Blumberg, 1877, finds a larger number of longitudinal nerves than the last author and Nitsche finds ten strands from the neck region of *Taenia*.

Niemeic, 1886, finds a nerve ring in the rostellum and eight nerves coming from the ring. As each one leaves there is a swelling on the ring with small ganglion cells. A commissure surrounds the central ganglion. Other commissures were also found in this region.

In *Acanthobothrium* Pintner, 1881, was one of the first to describe the nervous system. Niemeic shows it with branches to the forward region, a ring commissure below the main ganglion and with two thick and other thinner longitudinal strands.

In *Tetrarhynchus* Lang, '82, was one of the early students. Figure 11-L, is from another species which resembles the condition in *Tetrarhynchus*.

The nerve cells of Cestoda differ greatly in size. Niemeic gives figures from the cells and nuclei of a number of species. He finds them to be from 12 x 16 microns to 28 x 34 microns cell body; nucleus, 5 x 8 microns to 9 x 13 microns.

Among the more recent literature is the work of Tower, 1900, on *Moniezia*. The complicated nervous system of this species is shown in Fig. 11, A.

Kofoid and Watson, 1910, call attention to the similarity of the nervous structures in the scolex of cestodes with that of the posterior region of some trematodes, and they suggest that with *Gyrocotyle* as an intermediate type the scolex part of the nervous system of tape worms represents the caudal end of the worm.

The only sense organs of tape worms are represented by very simple end knobs of sense cells in the cuticle. Fig. 11, B.

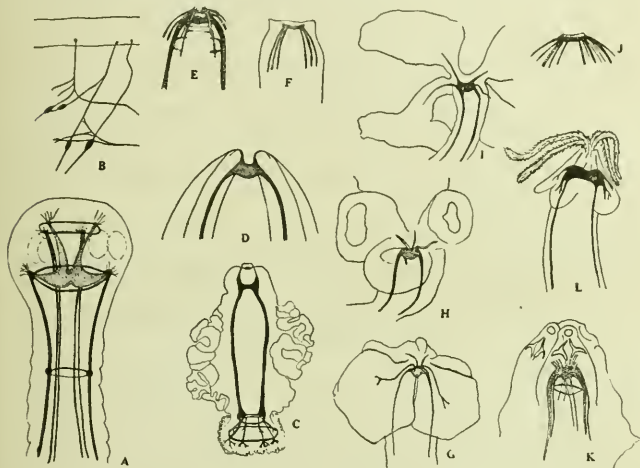


Fig. 11. NERVOUS SYSTEM CESTODA. A. *Moniezia*, Tower. B. Sensory cells ending in hypodermis, Zernecke. C. Nervous system *Gyrocotyle*, Kofoid and Watson. D, E, F, G, H, I, J, K. Central nervous systems scolex end several species of Cestodes. L. *Rhynchobothrium*, Lang.

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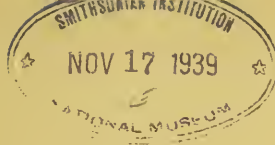
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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor

Claremont, California, U. S. A.

A List of California Arachnida

V. PHALANGIDA OR HARVEST MEN

L. Myers

First three figures from Banks.

COSMETIDAE. Second pair of legs without endites. Pedipalps shorter than the body. Eye tubercles low.

Cynorta bimaculata Bks. San Diego. No spines or tubercles at caudal end of the body.

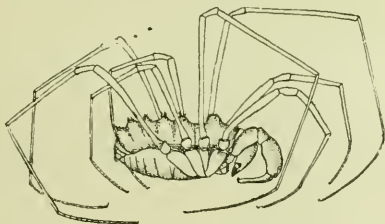
PHALANGODIDAE. Hind coxae united to first abdominal at base, free at apex. Second pair of legs distinct endites. Pedipalps large. Spiracles indistinct.

Sitalces californicus Bks. Martin Co. and Mt. Shasta.

Sclerobunus robustus Pack. Mt. Shasta region.

Scotolemon californica Bks. Alabaster Cave, Calif.

PHALANGIIDAE. Last segment of the pedipalps long and armed with a claw. Coxa of fourth leg is united near its base on the posterior side to the tracheal sternite of the abdomen. Tibial spiracles are present.



Protolophus tuberculatus Bks. Gray to brown, more or less mottled. Abdomen often red-brown. Claremont, Santa Catalina, Santa Rosa.

P. singularis Bks. Near San Diego.

Mitopus californicus Bks. Los Angeles. Gray above, mottled, femora and tibia brown.

Globipes spinulatus Bks. Red-brown, base of legs yellowish. Eye tubercle low. S. Calif.

Leptobrunus californicus Bks. Whitish above, mottled with brown and black. Indefinite vase mark. Los Angeles and S. Calif.

Eurybunus brunneus Bks. Body very smooth; fourth leg nearly as long as second. S. Calif.

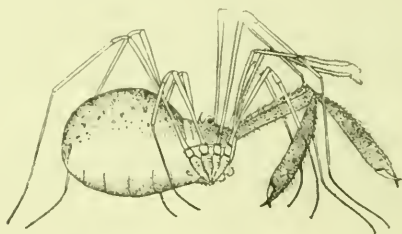
E. spinosus Bks. Gray above, black mark on each side of base of abdomen. Femora I and III brown, with a pale ring on middle.

Leiobunum bimaculatum Bks. Dark brown, two prominent yellow spots. Near San Diego.

L. exilipes Wood. Female dark rose mark on dorsal side. From N. Calif. to Claremont. Common in mts. near Claremont.

ISCHYROPSALIDAE. Last segment of pedipalps shorter than next to last, without claw. Coxa of fourth leg not fused with adjacent sternite of abdomen. No tibial spiracles.

Taracus spinosus Bks. Pale yellow, claw of mandibles red-brown. S. Calif.



T. pallipes Bks. Mt. Shasta.

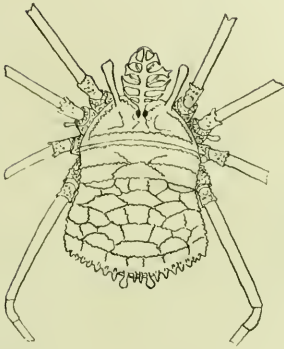
NEMASTOMATIDAE. Stermites of abdomen free, overlapping, and without median divisional sulcus. The first and second abdominal sternites narrowed in front and extended between coxae.

Nemastoma modesta Bks. Back brown to red-brown. Legs pale. From eye tubercle backwards a row of tubercles, flat tops broader than base. Mt. Shasta, Claremont.

TROGULIDAE. Stermites of abdomen except genital and anal, fused, do not overlap. They have a median longitudinal sulcus. The first and second abdominal sternites widely rounded in front and overlap the proximal parts of the two posterior pairs of coxae.

Ortholasma pictipes Bks. Eye tubercle. Four to five openings on a side. Humboldt Co. and Mt. Wilson.

O. rugosa Bks. Common in S. Calif.



Dendrolasma mirabilis Bks. Coulterville, Calif.

Pomona Jour. Ent. 1911, p. 412. Bull. III Nat. Hist. 1889 N. 3, p. 99.

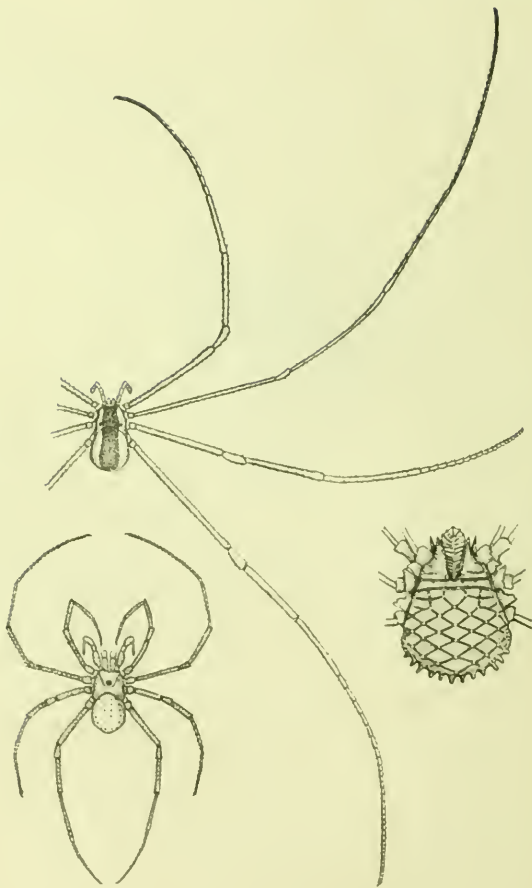


Figure above, *Leioibunum bimaculatum*. Below, *Protolophus tuberculatus*. Figure at the right, body of *Ortholasma pictipes*.

A List of California Arachnida

VI. ACARINA OR THE MITES AND TICKS

F. Cox, P. Jahraus, W. Moore

Figures from Hall, except the plate.

EUPODIDAE. Body divided into cephalothorax and abdomen. Palpi without thumb. Beak small. Eyes when present near posterior edge of the cephalothorax. Body soft. Moderate to very long legs. Palpi short. Mandibles small but chelate. Mostly on ground, predaceous.

Eupodes brevipes Bks. Body red, legs clear. Slender. Sides concave. Laguna Beach.

Rhagidia pallida Bks. Under stones, Claremont.

Penthaleus bicolor Bks. Spherical, dark body, red legs. Common Claremont.

BDELLIDAE. Snout mites. Skin not hard. Palpi 4-5 segments. Cephalothorax large, well separated from abdomen. Palpi large geniculate and bearing long tactile bristles. Mandibles chelate. Body elongate. Lives in moss, dead laves, etc. Predaceous.

Bdella peregrina Bks. Claremont, Chino.

B. lata Ewing. On live-oak, under stones, etc. Claremont.

B. californica Bks. Body white, legs, palpi yellowish beyond base. Body narrowed in front to beak. Eye each side cephalothorax, four hairs in front, longer one each side beyond eye. Abdomen a few short hairs above. Legs rather slender. Claremont.

B. utilis Bks. from black scale.

ANYSTIDAE. Coxae contiguous, radiate. Legs slender, bristly. Body few hairs. No dorsal groove. Tarsi not swollen.

Erythraeus posticatus Bks. Palpi slender, a long thumb. Body dark red, legs pale. From bark of eucalyptus, Claremont.

E. augustipes Bks. Under stones, Claremont.

E. hiltoni Bks. Claremont.

Erythraeus sp. not mature, on phalangid, Palmer's canyon near Claremont and on horned toad Laguna Beach.

Tarsotomus terminalis Bks. Body slightly constricted in middle. Two eye spots in cephalothorax. Many long erect bristles. Claremont.

T. macropalpis Bks. Large species sparse bristles, body nearly twice as long as broad. Claremont.

TETRANYCHIDAE "Red spiders". "Palpus with thumb, body well clothed with hairs. Legs I and II without spine-like processes. Coxae not radiate. Legs usually in groups of two each. No dorsal groove on cephalothorax. Tarsi not swollen. Mandibles for piercing. Hair on body usually in four longitudinal rows. Body oval, few bristles. Suture between second and third pair of legs. Red, two to four eyes. Pedipalps four jointed, usually a strong claw on next to last joint.

Tetranychus simplex Bks. Date palm, El Centro.

T. mytilaspidis Riley. S. California on orange. This is the "citrus red-spider". Red in color, bristles arise from tubercles.

T. sexmaculatus Riley. In San Diego Co. in colonies in depressions covered with silk.

T. bimaculatus Harves. On fruit trees, and food plants. Common on many plants.

Tetranychoides californicus Bks. On citrus trees.

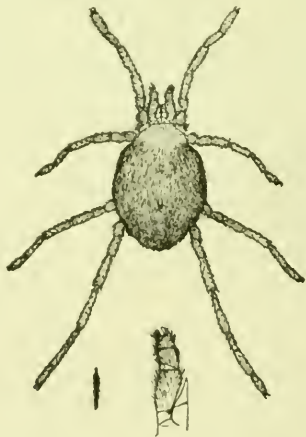
Tenuipalpus californicus Bks. Small flat, sometimes on citrus trees. Little damage.

Caligonius terminalis Bks. Red body. Chula Vista, San Diego. On lemon leaves, not abundant or important.

Bryobia pratensis Garman. In East called clover mite. In Calif. called almond mite. S. Calif. and north. Long front legs, four scale-like projections on front margin.

RHYCHLOPHORIDAE. Skin not horny. Cephalothorax without special hairs. Legs in two groups. Palpi with last segment a thumb, while next to last ends in a claw. Cephalothorax large on same plane with abdomen, dorsal groove present.

Rhyncholophus moestus Bks. Red. Monrovia.



R. arenicola Hall. Bright red or straw color. Dry sand Laguna Beach.

R. gracilipes Bks. Santa Rosa I.

TROMBIDIIDAE. Harvest mites. Palpi geniculate, ending in one or two claws and with a thumb at the end. Coxae in groups. Body thickly dotted with short hairs, tarsi often swollen. Cephalothorax small and almost completely hidden by the projection of the anterior part of the abdomen. Mandibles for biting. Body globular.

or elongate, red, hairy, usually transverse suture between second and third lgs. Eyes often stalked. Legs with two claws. Larva three pairs of legs. Parasites on spiders, flies, etc.

Trombidium perscabrum Bls. Red, length 1.4 mm. Peculiar knobbed hairs. Claremont, also fresh-water pool Laguna Beach.

T. claremonti Bks. Evey's canyon near Claremont.

T. parificum Bks. Dark red. From ants' nests, and from Evey's canyon.

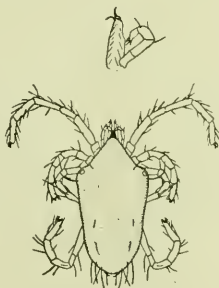
Trombidium sp. Near Camp Baldy.

HYDRACHNIDAE. Fresh-water mites. Mouth-parts not in a beak. Usually suckers near genital openings. One or two pairs of eyes. Body oval or spherical, sometimes of large size, often bright colored. Legs usually five-jointed with swimming hairs. Often attached to aquatic insects.

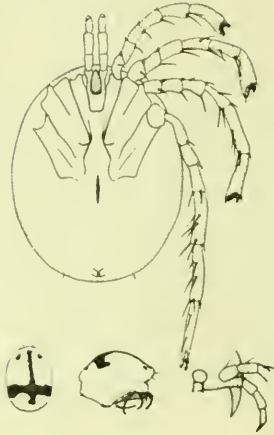
Hydrachnid. Larvæ on notonectid, Claremont, on carabid beetle Laguna Beach.

Hydracna sp. "Probably new" Banks. Large dark red-brown, spherical, found in great abundance at Laguna Lakes July and August, 1915.

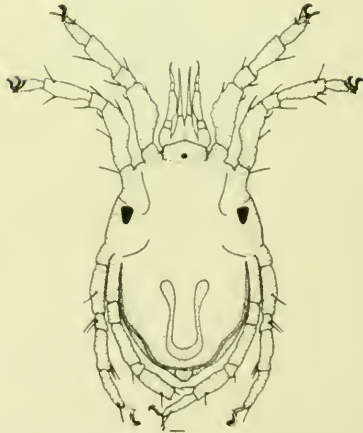
HALACARIDAE Salt-water mites. Body rather elongate. Usually a suture between the second pair of legs. Rostrum often large. Usually three eyes. No swimming hairs on legs. Mouth in a distance back, no ventral suckers. Lives upon algae.



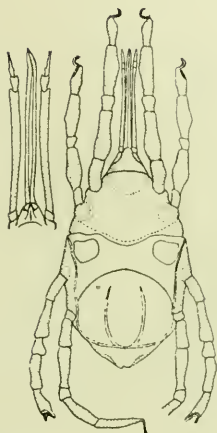
Pontacarus californicus Hall. Under stones low tide.



Pontarachna cruciata Hall. Body highly arched globular. Laguna Beach tide pools.



Copidognathus curtus Hall. Tide pool Laguna Beach.



G. californicus Hall. Tide pool Laguna Beach.

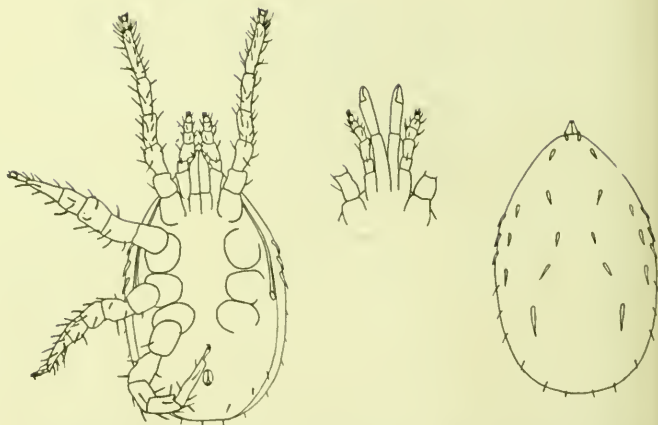
GAMASIDAE. Scavenger mites, body broad, short legs, no eyes. Mandibles usually chelate. Pedipalps five-jointed, legs six-jointed ending in two claws. First pair of legs inserted at one side of the mouth opening. Male genital opening usually on anterior margin of sternal plate.

Gamasus californicus Bks. Body yellowish, legs paler.

Parasitus frontalis Bks. From wild mouse, Laguna Beach.

Parasitus sp. Free living, Claremont, Chino.

Macrocheles sp. Chino swamp.



Seius orchesoideae Hall. Female light straw color. Male lighter. Dorsal plate over whole back. Ovoid. From the amphipod *Orchesoidea californiana*, Laguna Beach.

Laelaps pilosula Bks. Santa Rosa I.

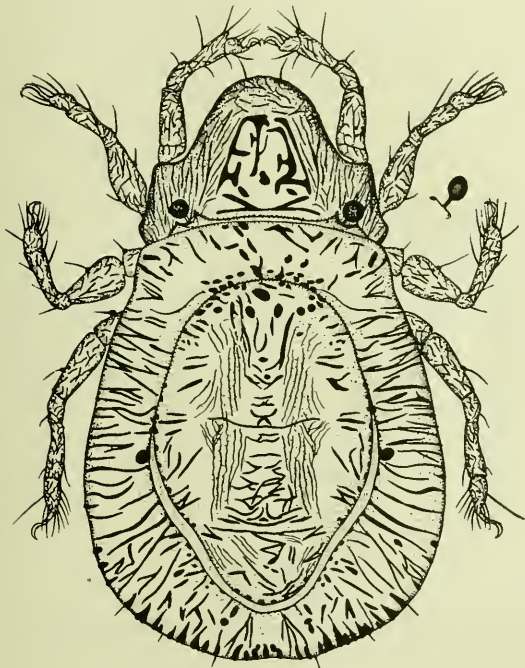
UROPODIDAE. With a distinct spiracle on lateral stigmal plate above 3-4 coxae. First pair of legs inserted in same opening as mouth-parts. Back of body extending towards and hiding mouth-parts from above.

Uropoda sp. Young on carabid beetle and on *Scolopendra*.

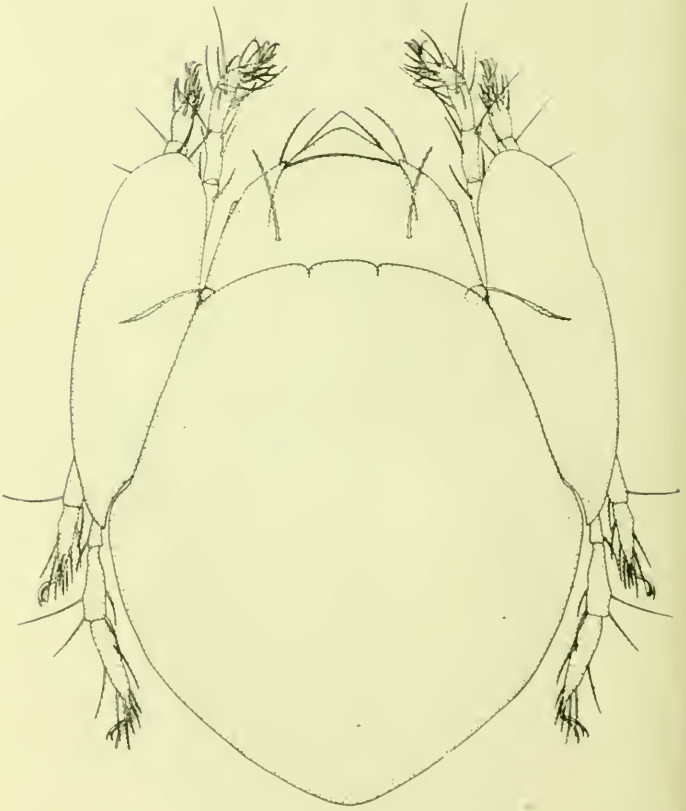
DERMANYSSIDAE. Mandibles for piercing. Body sometimes constricted. Parasitic on vertebrates.

Dermanyssus gallinae Redi. Parasitic on chickens.

ORBATIDAE. Horny beetle mites. Cephalothorax with a special hair on the posterior lateral vertex. Skin hard. Abdomen with wing-like expansions. Body minute, divided into two parts by transverse suture. Mouth-parts small hidden. Live upon vegetable or decaying material. Palpi five-jointed.



Hermannia hieroglyphica Hall. Brown, black markings, mandible chelate. Rough deep sculpturing. Claremont.



Oribata humida Hall. Color chestnut, polished. Abdomen with wings. Mandible chelate. Laguna Beach under board.

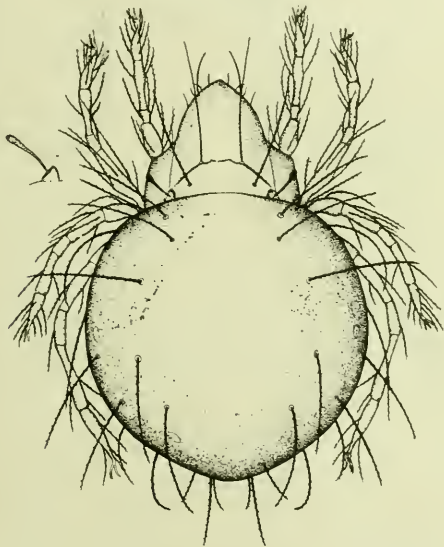
O. californica Bks. Abdomen red-brown, basal joints of legs brown, rest yellowish-brown. Cephalothorax brown. Mt. Shasta.

O. alata var. *californica* Hall. Black, polished abdomen with wings. Claremont.

Phthiracarus cryptopus Bks. Body brown, yellowish at base of abdomen. Smooth shiny, legs pale. Cephalothorax six bristles above, anterior pair shorter than others. Abdomen large high, about one-fourth longer than broad, two rows of fine hairs each side above. Legs very short and hairy. Claremont.

Eremaeus bilamellatus Hall. Claremont under leaves.

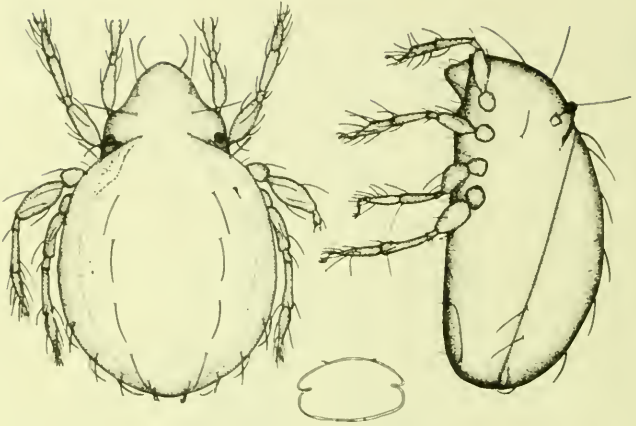
E. modestus Bks. Trunk and branches orange trees. Live upon plant life growing on trees.



Notaspis pectinata Hall. Yellow brown, smooth, polished. Claremont, Calif.

N. bilamellatus Hall. Light chestnut, smooth not polished, without wings. Mandibles large chelate. Follows Michael, near *N. burrowsi*, but differs in having no hairs on abdomen. Under stones Claremont.

N. nuda Hall. Black, smooth polished. Mandibles chelate. Under boards, Claremont.



Paraliodes incurvata Hall. Dark brown, almost black, stout chelate.



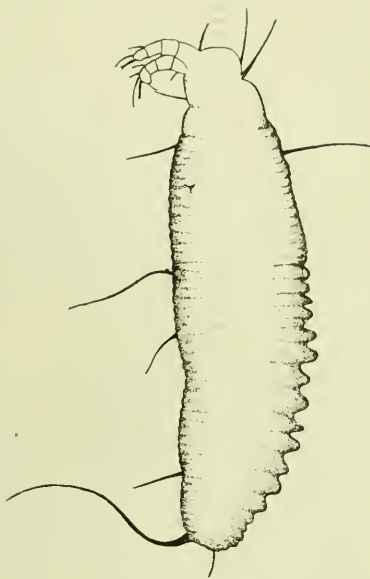
Lahmannia spinosa Hall. Legs colorless, skin clear. Mandibles heavy chelate.

Liacarus modestus Bks. Body pale, red-brown, legs pale yellow. Cephalothorax four ridges, and four bristles above.

ERIOPHYIDAE Gall mites. Body small, worm-like caudal end elongate. No eyes. Two pairs of legs. Galls always open.



A



B

Paraphytoptus californicus Hall. (Possibly may be *P. peravorus*.) Gall on *Artemisia*. Abdomen annulate.

Eriophyes oleivorus Ash. Silver mite.

TARSONEMIDAE. No ventral suckers. Legs end in claws, body divided into cephalothorax and abdomen. Female with clavate hairs between legs one and two.

Tarsonemus approximatus Bks. Pomona, Calif. Under *Citricola* scale.

T. assimilis Bks. From red scale. Whittier.

TYROGLYPHIDAE. Small, elongate, smooth. Legs alike. Chelate mandibles, no eyes. Palpi close against mouth parts. Legs long, clavate hair on tarsi of one and two. Not parasitic except a few on bees. Mostly live on organic matter. Cheese mites, etc.

Tyroglyphus longior Gervais. Hairy bristles on body, long tarsi. Calif.

T. americanus Bks. From lemons in storage S. Calif.

Trichotarsus xylocopae Donn. European species found on *Xylocopa californica*.



Rhizoglyphus longistriatus var. *californicus* Hall. From Banning, injury to bark of apple tree.

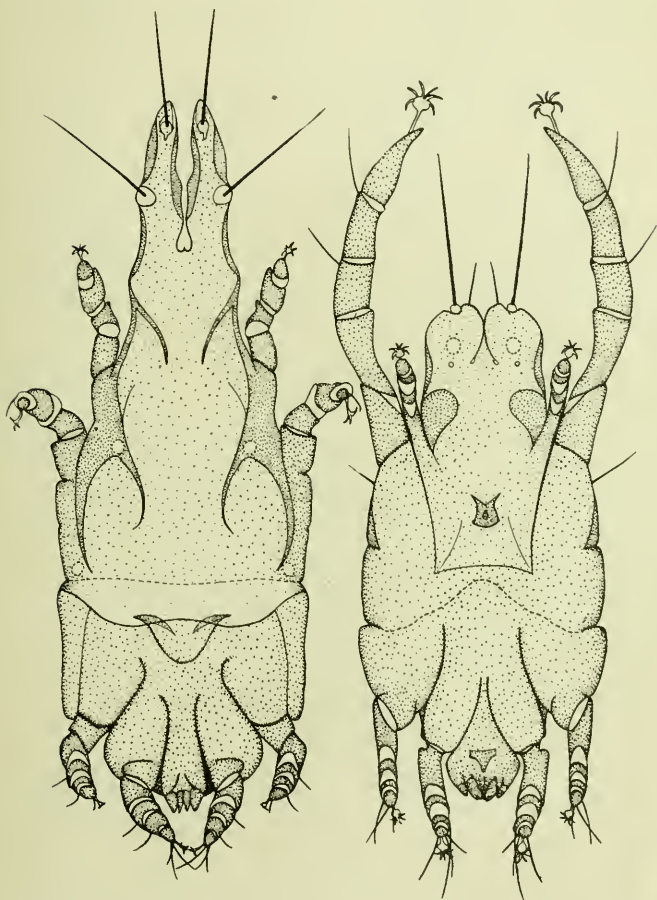
R. tarsalis Bks. Spreckels, Calif., on sugar beet.

R. rhizophagus Bks. On onions, Calif.

Glyciphagus obesus Bks. Berkeley, Calif.

Carpoglyphus passularum Hering. From Fresno on dry figs.

ANALGESTIDAE Bird mites. Small, elongate, transverse striations on the body.



Pteronyssus bifurcatus Hall. Integument strongly chitinized, from *Peterochelidon lunifrons*.

THE TICKS

ARGESIDAE. No dorsal shield, head hidden under front of body. Skin rough coxae usually contiguous or nearly so. Tarsi without apical pulvillum.

Argas miniatus Koch. Riverside.

Ornithodoros coriaceus Koch. San Francisco and Santa Clara Co.

O. megnini Dug. Red brown to black. Los Angeles.

O. talaje Guer. San Clemente Island.

IXODIDAE. Back covered by a horny shield, head distinct from the body. Anus in middle of ventral side. Skin finely striated. Tarsi with pulvillum. Male almost entirely covered with dorsal shield. Female shield only on anterior part of dorsum.

Ixodes hexagonus. Santa Clara Co., Mt. Shasta.

I. californicus Bks. Laguna Beach, Claremont, Santa Clara Co. On fox and deer, dog. Shield red-brown, paler in middle, body brownish or yellowish, coxae brown, legs paler. Few hairs. Shield long, finely punctured.

I. angustus Neum. Siskiyou Co.

I. sculptus Neum. Santa Cruz Mts., Calif.

I. pratti Bks. Claremont.

Argas miniatus Koch. Large ticks, exact location of capture not known. Calif.

Ornithodoros megnini Duges. Mt. Shasta; also S. Calif.

Dermacentor occidentalis Neum. Mts. near Claremont and foothills.

D. reticulatus Feb. Palo Alto and Mt. Shasta.

D. parumapertus Neum. Lake Side, Calif.

D. occidentalis Neum. Santa Clara Co., Humboldt Co. From deer.

Ceratixodes signatus Birula. Cormorant, Pacific Grove.

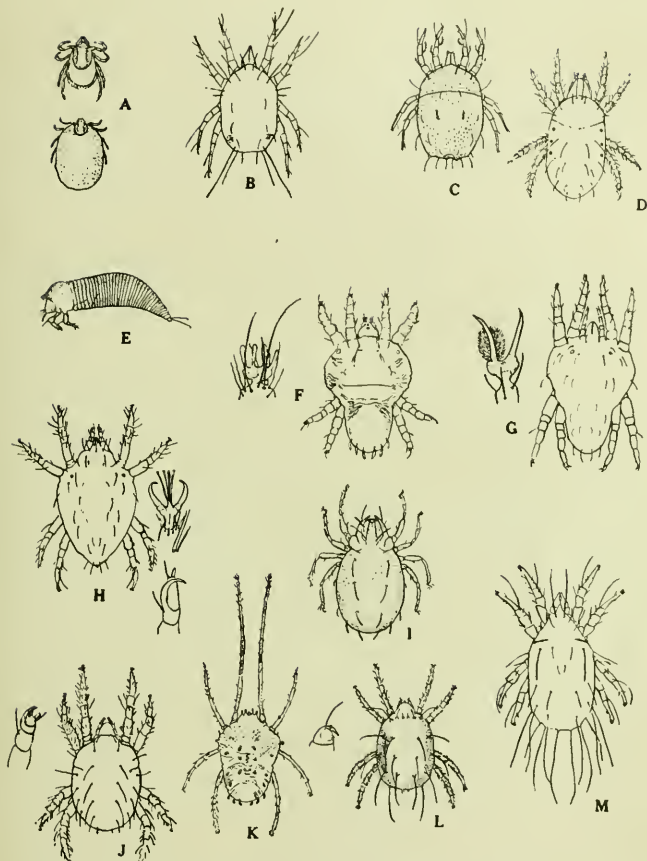
Amblyomma maculatum Koch. Tulare Co., Calif.

A. cajennense Beh. San Diego.

Haemaphysalis leporis-plaustri Pack. On rabbit, Claremont.

H. concinna Koch. Claremont, on rabbit.

Jour. Ent. Zool. VI, 1914, pp. 56-60. VIII, 1916, p. 12. Trans. Am. Ent. Soc. XXI, 1894, p. 22. Proc. Calif. Ac. Sc. Zool. III, 1904, pp. 365-369. Hubbard's Orange G. Insects 1885, p. 216. Jour. N. Y. Ent. Soc. 1904, pp. 54, 55. 1st Laguna Report. Pomona Jour. Ent. II, p. 280, III, p. 510. U. S. Dep. Agr. Tech. ser. 13, 1906, pp. 12, 20. Trans. Lin. Soc. XI, 1815, p. 397. Mem. Soc. Zool. Fr. 1899, p. 136. Arch. f. Naturges. X, 1844, pp. 219, 237. La Natur Mex. VI, 1883, p. 196. Ent. Syst. IV, 1874, p. 428. Banks, Tyroglyphidae, U. S. Dep. Agr. Tech. ser. 13, 1906. Banks, Iodoidea, U. S. Dep. Agr. Tech. ser. 15, 1908. Banks, Acarina U. S. Nat. Mus. 1904. Quayle, Red spiders and mites of citrus trees, Bull. 234, Berkeley, 1912.



IXODIDAE A. *Haemaphysalis leporis-palustris*, fresh and gorged female. TYROGLYPHIDAE B. *Carpoglyphus passularum*, C. *Glyciphagus obesus*. ERIOPHYIDAE E. *Eriophyes oleivorus*. TETRANYCHIDAE D. *Tetranychus sexmaculatus*, F. *Tenuipalpus californicus*, G. *Tetranychoides californicus*, H. *Caligonius terminalis*, J. *Tetranychus bimaculatus*, K. *Bryobia pratensis*, L. *Tetranychus mytilaspidis*. ORBATIDAE I. *Eremaeus modestus*. TYROGLYPHIDAE M. *Tyroglyphus americanus*.



VI. Nemertinea

The first work of any importance which deals with the nervous system of these worms is that of De Quatrefages in 1846. He describes the central nervous system as composed of two distinct lateral lobes united below and above by commissures. From the lateral lobes two more or less isolated longitudinal bands extend themselves towards the posterior end of the animal. So far as the figures are concerned this early work is even more detailed than that of M'Intosh in 1873. The more recent information about this interesting group has been furnished especially by Hubrecht in numerous papers from 1875 to 1887. Although the cellular details are not shown, the relative position of the central fibrous core is given in relation to the surrounding nerve cells. He also clearly distinguishes the dorsal median nerve springing from the slender dorsal commissure. The dorsal and ventral lobes of the brain are shown more clearly than in earlier writings. In *Eupolia* a dorsal, middle and ventral lobe are shown.

Hubrecht in his two papers of 1887 suggests the nemertineans as a group of animals valuable in tracing the relationship of the vertebrates and invertebrates. He bases his hypothesis largely upon the arrangement of the parts of the nervous system. In the group there is some variation in the extent and position of the lateral nerve cords and in some, the mouth opens behind the brain and in some in front of the brain. Such facts as these give suggestions of an intermediate condition between annelids and arthropods on the one side and vertebrates on the other. Other writers have compared the large lateral nerves of nemertineans with the central nerve cords of some round worms.

Bürger in a number of works from 1883 to 1895, has made a considerable study of the nervous system by various methods. He has also studied the histological details of the nervous system. His papers are the most comprehensive and important in this field. Bürger describes the nerve cells as all unipolar and uninclosed in special membranes. He classifies nerve cells as follows: (1) The smallest cells sensory in nature; (2) medium sized cells; (3) large cells; (4) very large cells, the so-called "Neurocorde" cells.

Montgomery, 1897, agrees with Bürger in many respects, such as unipolar condition of the nerve fibers, but these are composed of "a homogeneous unstaining axis cylinder which is probably fluid and a fine spongioplasmic layer."

In *Cerebratulus*, the large nerve fibers differ from the others in size. They do not give off collaterals but divide dichotomously and are arranged segmentally. The largest ganglion cells are present in three pairs in the ventral brain lobes and are distributed irregularly along the lateral cords, but are absent in both ends. In the

lateral cords they increase in number posteriorly and are more abundant on the dorsal side. In each lateral cord both dorsally and ventrally are radial clusters of medium sized cells showing a bi-lateral arrangement.

Haller, 1889, shows a neuroglia network in *Cerebratulus* and an anastomosis between the branches of multipolar ganglion cells.

The nemertineans are divided into groups somewhat by the position of the nervous system in relation to the body-wall. The more primitive condition seems to be when the brain and chief branches are outside the muscle layers, in the epithelium or below the basement membrane. In some the nervous system is found in the muscle layers of the body-wall and in others the brain and chief nerves lie in the parenchyma internal to the muscle layers.

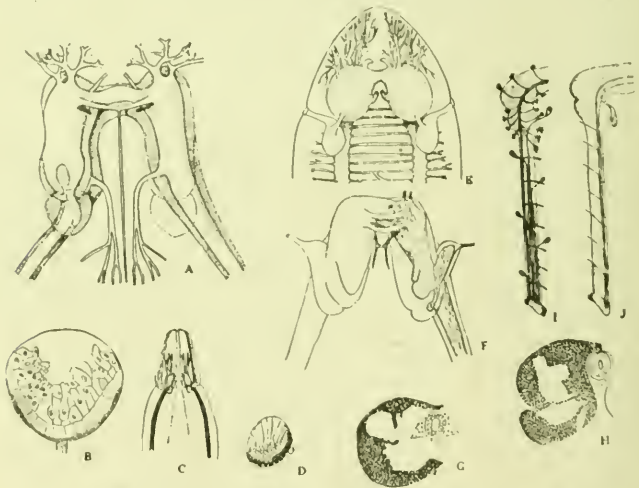


Fig. 13. NERVOUS SYSTEM AND SENSE ORGANS OF NEMERTINEA. A. Nervous system of *Cerebratulus* showing chief nerves and the position of the central fibrous mass, Hubrecht. B. Section of eye of *Drepanophorus*, Hubrecht. C. Diagram of head end of *Cerebratulus*. D. Section of eye of *Lineus*, Punnett. E. Brain of *Drepanophorus*, Hubrecht. F. Brain of *Eupolia*, showing fibrous core on the right, Hubrecht. G, H. Cross sections through brain of *Eupolia*, left side and oesophagus shown in each. I, J. Scheme of some nerve cells and fibers in the lateral cord and ventral ganglion in *Anopla*, and *Drepanophorus*, Bürger.

Hubrecht, '87, suggests that the more primitive nervous system of these animals has a most complicated intricate network of peri-

pheral nerve tissue. This network suggests the "most ancient arrangement of the nervous tissue." In the more highly specialized forms, the brain and lateral nerves are more concentrated. Probably all nemertineans have more or less peripheral nerve networks even though Hubrecht might not have seen them by his methods, but the fact remains that those forms in which the network is especially marked are more primitive because of it. Montgomery believes that Haller is mistaken as to the multipolar condition of these cells.

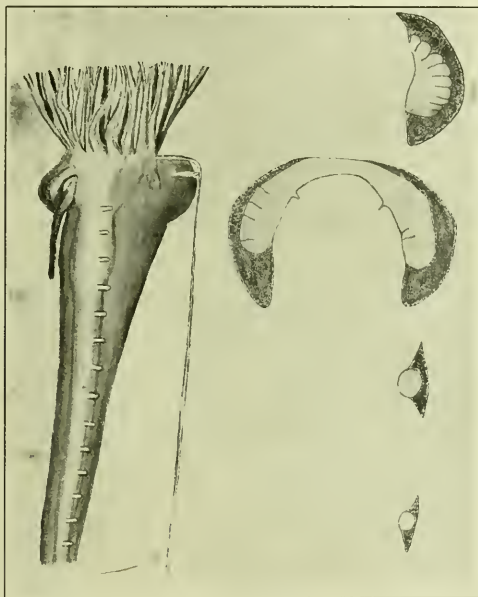


Fig. 14. Reconstruction of the nervous system of *Carinella* shown from the ventral side. Figure at the left, side view of a reconstruction of the upper portion of the central nervous system of *Carinella*. The figures at the right are from cross section taken at various levels. The upper and the two lower figures are from one side only. X75, Hilton.

In general the central nervous system of the Nemertinea is as follows: A brain composed of two ganglionic masses at the anterior end of the body, one on each side of the proboscis. These are united

by ventral and dorsal commissures passing about the proboscis. The dorsal band is often more slender than the ventral and from it a slender dorsal nerve runs the length of the body. Each lateral brain lobe is often partly divided into a dorsal and ventral lobe. From each lateral ganglion a large nerve trunk passes back and may unite with its fellow of the opposite side just above the anus.

Nerves are given off from the brain to the eyes when present, and to anterior portions of the body. Two branches come off from the dorsal commissure and run to the proboscis. The so-called vagus nerves arise from the internal borders of the brain not far from the origin of the lateral cords. They are sometimes united by a commissure and then pass down the oesophagus.

Eyes are usually present along the sides of the head, sometimes a single pair, at other times one or more groups on each side. The eyes in their simplest conditions are mere pigment spots, in others there is a clear area filled with fluid which is supported by strands from cells and held by a limiting membrane. Sensory cells are connected with the brain by fibers and with pigment at the outer side. The sensory area seems to be like rods in certain forms.

In some cases otocysts have been found on the surface of the brain. At the anterior tip of the head groups of cells bear long bristles. In some, these areas are retractile. Taste has been suggested as the function of these "frontal" organs. The so-called "side" organs occur as a pair of epithelial patches on each side of the body in the region of the excretory pore. These have an abundant nerve supply but their function is unknown.

In most forms a peculiar pair of organs is found in the head region in close connection with the brain. Hubrecht suggests that they may be respiratory. Bürger thought that they might be organs used for determining the condition of the water. They may be shallow depressions, longitudinal or slit-like or the slit may be at right angles to the body. In some, ciliated ducts pass inwards and penetrate into special lobes called the *cerebral organs*.

Thompson, 1908, in *Cerebratulus lacteus* finds six ventral commissures from the ventral lobes of the brain. Some of these come from the fibrous core and some come from the cellular sheath of the brain. Other commissures are found beyond the brain.

Six pairs of "neurocord" cells and one unpaired cell are found in the ventral lobes of the brain. There is probably individual variation as to their number.

The brain is complex but resembles in its form and commissures that of the tubularian worms.

Coe and Ball, 1920, in *Nectonemertes*, find both dorsal and ventral commissures well developed. Cerebral and frontal organs are lacking.

In the blastula of *Cerebratulus* cells on the apex of the larvae develop cilia and sink below the general surface. This forms the apical sense organ of the larva.

The brain of the adult develops by thickenings of the apical discs.

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William A. Hilton, Editor

Claremont, California, U. S. A.

A List of California Arachnida

VII. ARANEIDA OR TRUE SPIDERS

M. Moles, I. Johnson

AVICULARIIDAE. Chelicera project forward and claw moves vertically. Two pairs of book-lungs. Coxae of pedipalp like the legs, lacks a distinct endite.

Bothriocyrtum californicum Camb. Los Angeles Co., etc. Common trap door spider.

Eutychides versicolor Simon. Santa Clara Valley.

Hexura picea Sim. Mariposa Co.

Brachythele longitarsis Sim. Calif.

B. theveneti Mariposa Calif.

Atypodes riversi Camb. Black Mt., Calif.

Eurpelma californica Auss. Santa Cruz and south to Claremont.

E. rileyi Mar. Calif.

E. leiogaster Auss. Calif.

E. marxi Simon. Calif.

Hexura fulva Chamb. Claremont.

Nemesoides hespera Chamb. Claremont.

Amblyocarenum talpa Bks. Calif.

Aptostichus atomarius Simon. Calif.

A. clathratus Simon.

A. standfordianus Ch. P. Smith, San Francisco Co.

Avicularia californica Bks. Calif.

Hebestatis theveneti Simon. Calif.

ATYPIDAE. Distinguished from the previous family by more complicated palpus of male. Coxa of pedipalps bears a large conical lobe. They also have a large endite on the coxa of palpus.

Aliatypus californicus Bks. Santa Clara Valley.

ULBORIDAE. Spin orb-webs. Have cribeillum and calamistrum. Dark eyes, lateral ones farther apart than the two pairs of median ones. Posterior metatarsi much curved and armed below with a series of spines.

Ulbosus californicus Bks. Napa Co. and near Claremont.

DICTYNIDAE. Cribeillum and calamistrum. Anterior median, eyes dark, others white. Lateral eyes on each side nearly touching. Tarsi of legs three claws. Irregular web.

Amaurobius nevadensis Simon. Northern counties.

A. nigrellus Chamb. Claremont.

A. pictus Simon. San Francisco.

Dictyna sublata Hentz. Lake Tahoe to Claremont.

D. volucripes Keyser. Palo Alto to Claremont.

D. calcarata Bks. San Pedro.

D. mians Chamb. Claremont.

- Dictynna pallida* Bks. Mt. Shasta.
Dictyolathys californica Bks. Palo Alto.
Parauximus tradatus Chamb. Claremont.
Auximus pallescens Chamb. Claremont.
A. latescans Chamb. Claremont.

FILISTATIDAE. Eyes massed in small group, anterior median eyes dark, round, rest oval or angular, white. Chelicerae small without condyle, chelate.

- Filistata hibernalis* Hentz. Mill Valley to Claremont.

DYSDERIDAE. Six eyes. Four spiracles near base of abdomen. A pair of lung slits and a pair of tracheal spiracles. Coxae of first pair of legs long and cylindrical.

- Segestria pacifica* Bks. Mt. Shasta and Claremont.

SCYTODIDAE. Six eyes, one tracheal spiracle. All eyes white. No suture between labium and sternum.

- Diguetia canites* McCook. San Diego, Los Angeles.
Plectrocurys suprenans Chamb. Claremont.

- LEPTONETIDAE. Six eyes, small long legs, suture between labium and sternum.
Leptoneta californica Bks. Mt. Diablo.
Usoala gracilis Mark. Calif.

DRASIDAE. Eight eyes in two rows. Two tarsal claws. Four spinnerets widely separated. Tarsi with bundles of terminal tenent hairs.

- Drassudes californica* Bks. Sierra Co. and Martin Co.
D. celes Chamb. Claremont.
Megumyrmecion californicum Simon. San Francisco, Claremont.
Drassinella modesta Bks. San Francisco and Claremont.
Gnaphnsa californica Bks.
Pocilnchroa pacifica Bks. Sierra Co., Stanford and Claremont.
P. montana Em. Claremont.
P. concinna Sim. Calif.
Zelotes femoralis Bks. Claremont.
Z. maculatus Bks. Claremont.
Z. pacificus Bks. Santa Rosa I.
Z. taibo Chamb. Claremont.
Z. irritans Chamb. Claremont.
Z. gynethus Chamb. Claremont.
Z. ethops Chamb. Claremont.
Herpyllus augustis Bks. San Pedro.
H. californicus Bks. Lakeside, Calif.
H. talidus Bks. Los Angeles and Claremont.
H. pius Chamb. Claremont.
Sergolus bicolor Bks. Claremont.

Callilepis insularis Bks. Guadeloupe I., Claremont.

PHOLCIDAE. Very long legs, irregular webs. Tarsi of legs three claws, usually eight eyes. Group of three eyes on each side.

Pholcus phalangioides Fuessl. Los Angeles, Claremont.

Physocyclus golbosus Tacz.

Psilochorus californiae Chamb.

ZODARIIDAE. Legs nearly equal in size. Internal face of the endites is not furnished with serrula, but bears an apical scopula. Rostrum membranous and furnished above with a band of hairs.

Lutica maculata Marx. Calif.

THERIDIIDAE. Eight eyes. Three tarsal claws, comb on tarsus of fourth pair of legs. Chelicera no condyle.

Theridion tepidarium Koch. San Francisco, Claremont.

T. placens Keys. Calif.

T. differens Em. Palo Alto, Mt. Shasta.

T. fordum Key. Santa Cruz.

T. californicum Bks. Calif.

T. inconstans Curtis. Calif.

T. sexpunctatum Emerton. Mill Valley.

T. pictulum Bks. Calif.

Latrodectus mactans Fab. North to south, Catalina I.

Diplocephalus pictipes Bks. Claremont, Calif.

Argyrodus decorus Bks. Calif.

A. jucundus Camb. Los Angeles, San Pedro.

Euryopis funebris Hentz. San Francisco.

Steatoda grandis Bks. Claremont.

Lithyphantes tectus Keyser.

LINYPHIIDAE. Three claws, eight eyes. No comb on tarsus. Organs of stridulation. Dissimilar eyes. No lateral condyle or chelicerae.

Diplocephalus fasciatus Bks. Calif.

Linyphia arcuata Keyser. San Francisco.

L. digna Keyser. Palo Alto.

L. phrygiana Koch. Palo Alto.

L. rubrofasciata Keyser. Mt. Shasta.

Erigone californica Bks. N. Calif and Claremont.

Bathypantes pallidulus Bls. Calif.

ARGIOPIDAE. Orb-weavers. Three claws, eight eyes. Tarsi hairs, no comb.

Tetragnatha extensa Linn. Alameda Co.

T. laboriosa Hentz. N. and S. Calif.

Leucauge hortorum Hentz. Los Angeles.

Argiope trifasciata Forsk.

A. argentata Fsh. S. Calif.

A. aurantia Lucas.

A. avara Thorell. Calif.

Ordgarius cornigerus Hentz. Los Angeles.

Gasteracantha maura McCook. Claremont.

- G. cancriformis* Linn. Calif.
G. tetracantha Linn. Calif.
Meta menardi Latrelle. Claremont.
Cyrtophora californiensis Keyser.
Cyclosa index Cambs. N. Calif.
G. conica Pallas. N. to South.
Eustala anastera var. *conchlea* McCook. Calif.
Zella californica Bks.
Z. x-notata Clerck. Claremont.
Metargiope trifasciata Forsk. Claremont.
Aranea angulata Clerck. Claremont.
A. marmorea Clerck. Claremont.
A. curcurbitina Clerck. Claremont.
A. carbonaria Koch.
A. miniata Walck. Claremont.
A. bispinosa Keys. Calif.
A. conchlea McCook. Claremont.
A. oaxacensis Keys. Sitz. Palo Alto to Los Angeles.
A. displicata Hentz. Mill Valley, Mt. Shasta.
A. labyrinthea Hentz. Martin Co. to Claremont.
A. l. grinelli Coolidge.
A. nephiloides Camb.
A. trifolium Hentz.
A. patagiata Clark. N. Calif.
A. pacifica McCook. N. and S. Calif.
A. californica Bks. Calif.
A. gemma McCook. N. to S.
A. variolata Camb. Calif.
A. gosogana Chamb. Calif. desert region.
Leucauge argyra Walck. Calif.

CTENIDAE. Wandering spiders, usually. Eyes three to four transverse rows. Ends of endites clothed in dense uneven hairs. Two-clawed.

Titiotus californicus Simon. From Calif.

CLUBIONIDAE. Flat tubular nests, eight eyes in two rows, two tarsal claws. Lower margin of furrow of chelicerae distinct, armed with teeth. Tarsi usually with bundle of tenent hairs.

- Gayenna californica* Bks. Palo Alto, Mill Valley.
Chiracanthium inclusum Hentz. Mill Valley, Claremont.
Clubiona pacifica Bks. Claremont.
Olios fasciculatus Simon. Calif.
O. schistus Chamb. Claremont.
Anyphaena crebrispina Chamb. Claremont.
A. ruens Chamb. Claremont.
A. zina Chamb. Claremont.
A. incurva Chamb. Claremont.
A. nundella Chamb. Claremont.

Anachemmis sober Chamb. Claremont.
A. dolichopus Chamb. Claremont.
Namopsilus pletus Chamb. Claremont.
Micaria palliditarsus Bks. S. Calif.
Castaneira descripta Hentz. Claremont.
C. pacifica Bks.
C. tricolor C. Koch.
Trachelas tranquillus Hentz. Claremont Mts.
T. californicus Bks. Claremont.
Hilke trivittata Keys. Calif.

AGELENIDAE. Three claws, usually eight eyes. No scopula on tarsus. Trochanters not notched. Hind spinnerets very long. Funnel-web weavers.

Agelena pacifica Bks. N. Cal., Catalina I. and Claremont.
A. californica Bks. Stanford, Claremont.
A. naevia Hentz. Claremont and Catalina I.
A. rua Chamb. Claremont.
Tegenaria domestica Clerck. Claremont.
T. californica Bls. N. Calif and Claremont.
Cybaeus reticulatus Simon. Claremont.
C. minor Bks. Claremont.
Chorizomma californica Sim. San Francisco.
Cybacodes incerta Bks. Salton, Calif.
Coelotes esaptus Bks. Calif.

MIMETIDAE. Tibia and metatarsi of first two pairs of legs with very long spines and shorter between.

Mimetus intersector Hentz. Claremont.

THOMISIDAE. Crab-spiders. First and second pair of legs usually longer than third and fourth. Eyes small dark, two rows usually recurved. Lower margin of chelicerae indistinct, unarmed, upper unarmed or with one to two teeth.

Xysticus californicus Keyser. N. to S.
X. formosus Bks. Mt. Shasta.
X. ferox Hentz. Claremont.
X. gluosus Keyser. Claremont.
X. triguttatus Keys.
X. montanaensis Keys. Calif.
Coriarachne brunneipes Bks. Mt. Shasta.
Runcinia aleatoria Hentz. N. Calif.
Misumena vatia Clark. N. to S.
Misumessus pictilis Bks. Palo Alto.
M. pallidulus Bks. San Francisco.
Misumenoides aleatorius Hentz. Claremont.
M. californicus Bks.
Misumenops asperatus Hentz. Claremont.
M. californicus Bks.
M. importunus Keys. Calif.
M. diegoi Keys. Calif.

M. modestus Bks. Calif.

M. munieri Coolidge.

M. pallidulus Bks.

M. pictilis Bks.

Tmarus magniceps Keys. Los Angeles.

Thanatus coloradensis Keyser. N. and Claremont.

T. retentus Chamb. Claremont.

T. oblongus Walck. Palo Alto and south.

Philodromus rufus Walc. N. Calif.

P. californicus Keyser. N. Calif.

P. moestus Bks. Claremont.

P. pernix Blackwall. Claremont.

LYCOSIDAE. Wolf-spiders. Trochanters of legs notched. Lorum of two pieces one notched to receive the other. Eyes in three rows, posterior lateral eyes behind posterior median, first row of four small eyes, two back rows of two large eyes each.

Lycosa pacifica Bks. N. to Claremont.

L. brunneiventris Bks. Palo Alto, Claremont.

L. kochi Keys. Claremont, and Ontario Mt.

L. ferriculosa Chamb. Claremont.

L. piratimorpha Strand. Calif.

L. ramulosa McCook. Calif.

Pardosa sternalis Thorell. Claremont.

P. lapidicina Em. Claremont.

P. tuoba Chamb. Claremont.

P. californica Keys. N. Calif. and Claremont.

P. modica Blackw. Mill Valley, Mt. Shasta.

Sossippus californicus Simon. Claremont.

Pirata californicus Bks. Mariposa Co.

OXYOPIDAE. Legs long, three tarsal claws, no scopulae. Trochanters not notched. Eight eyes, dark. Anterior median eyes very small. Abdomen tapers to a joint behind.

Peuceetia viridans Hentz. Los Angeles.

Oxopes salitcus Hentz. Mill Valley, Palo Alto.

O. rufipes Bks. Mt. Shasta, Santa Clara.

ATTIDAE. Jumping spiders. Short body, stout legs, two tarsal claws, bright colors, conspicuous eyes.

Dendryphantes capitatus Hentz. N. Calif.

D. californicus Peck. Calif.

D. vitis Peck. Claremont.

D. femoratus Peck. Calif.

D. johnsoni Peck. S. Calif., Catalina I., Claremont.

D. guttatus Bks. Calif.

D. ardens Peck. Calif.

D. aeneolus Curtis. Palo Alto.

D. hartfordi Peck. Claremont.

D. nubilus Hentz. Calif.

D. opifex McCook. N. and Los Angeles Co.
Thiodina retarius Hentz. N. and S. Calif.
Pallenes signatus Bks. Los Angeles.
P. elegans Peck. San Pedro.
P. tarsalis Bks. San Pedro.
P. dolosus Peck. Calif.
P. californicus Bks. Calif.
P. griseus Peck. Calif.
P. pacificus Bks. San Francisco.
P. jucundus Peck. Calif.
P. speciosus Bks. Claremont.
P. hutchensoni Peck. Calif.
Epiblemum palpalis Bks. Palo Alto.
Metacyrba taeniola Hentz. Los Angeles, Claremont.
Marpissa melanognatha Lucas. N. Calif.
M. californica Peck. N. Calif.
Salticus scenicum Clerk. Santa Barbara I.
Attus dorsatus Bks. S. Calif.
Sidusa morosa Peck. N. Calif.
Sitticus claremonti Peck. Claremont.
Sassacus papenhoei Peck. Calif.
Attinella dorsata Bks. Calif.
Pseudicius siticulosus Peck. Calif.
Habrocestum morosum Peck. Calif.
Hycia robusta Bks. Calif.

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Ophiuroidea of the West Coast of North America

ARTHUR S. CAMPBELL.

This list represents those Ophiuroidea reported upon by H. L. Clark, J. F. McClendon, and others, at various times from the West Coast of North America, and especially from the coast of California. Specimens listed are mostly from deeper water; but a few are littoral.

Original references to each species are given as far as possible. Bathymetrical ranges given are either extremes or are the only point from which specimens are known.

There seem to be several restricted faunas represented in the list. It is quite possible that specimens of almost any of the list might be taken at other points off the coast, and thus extend the known range.

The purpose of the list is to clear up certain synonyms, to check the present literature so far as possible, to record more complete data concerning the distribution of forms likely to be taken nearby, and to know more thoroughly what we have.

Our work is by no means finished, but we feel the list may be of some aid to those undertaking the study of west coast forms.

OPHIURAE

OPHIODERMATIDAE.

Ophioderma panamensis Lütken. Add. ad Hist. Oph., 2, p. 193. 1859. Littoral. Panama to California.

Ophioderma variegata Lütken. 1859. Add. ad Hist. Oph., 2, p. 21. Littoral. Lower Calif.

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(Contribution from the Zoological Laboratory of Pomona College.)

VII. Round Worms

NEMATOIDEA. The central nervous system of nematode worms was early described as a whole by Bütschli who recognized a collar of nerve cells and fibers and longitudinal strands. Hesse, 1892, gives a clearer picture of the nervous system of *Ascaris* and others since that time have improved and elaborated upon these and other early suggestions. Especially noteworthy are the works of Goldschmidt, 1908-9, and Deineka, 1908, each very valuable although the two investigators disagree on many points.

The nervous system of *Ascaris* may furnish a good starting point in a discussion of the nervous system of the group. In this genus there is a circumoral ring about the pharynx near the anterior end of the body. Ganglion cells are not abundant. They are chiefly grouped about the origin of the nerves. The nerve ring gives off six or more longitudinal nerves of which the mid-dorsal and mid-ventral are usually the largest and are connected to each other by fine branches. At the caudal end the lateral nerves pass into two branches formed by the division of the ventral nerve. Just above this point the ventral nerve swells into the anal ganglion. In the male the anal ganglion gives off two lateral nerves which form a ring about the cloaca.

The nerve ring forms a plexus according to Goldschmidt, in that all fibers are connected to other parts, but the plexus is regular and not of the diffuse type as found in Coelenterata. Three cell types are found, sensory, association and motor. Besides the direct connection of cell with cell through their processes there is in places a true neuropile. Neuroglia cells are found but are not prominent. Deineka favors the neuropile method of interrelation more than Goldschmidt. This author also has demonstrated the neurofibrillar arrangement of the material with the nerve cells and has shown rather elaborate interrelations between the fibrils of associated cells. He shows nerve terminations in muscle and sensory endings in the skin of the body. Aside from the general surface of the body the three papillae about the mouth are the only sense organs. These are supplied by six short nerves running from the nerve ring.

With free living nematodes but little has been done. In *Enoplas* Hilton, 1920, a very marked head ganglion above the mouth has two strands running backwards to the thick mid-ventral nerve strand and from the dorsal side a slender dorsal nerve runs the length of the body. The ganglion is rather complex in structure. From an inner group of nerve cells, fibers run forward to the sensory epithelium of the tip of the snout and three eyes, one dorsal and two ventro-lateral are composed of pigment and clear area in front.

Magrath, 1919, in *Callanus*, gives a good account of the nervous system of this simple nematode. In this as in other forms, there is

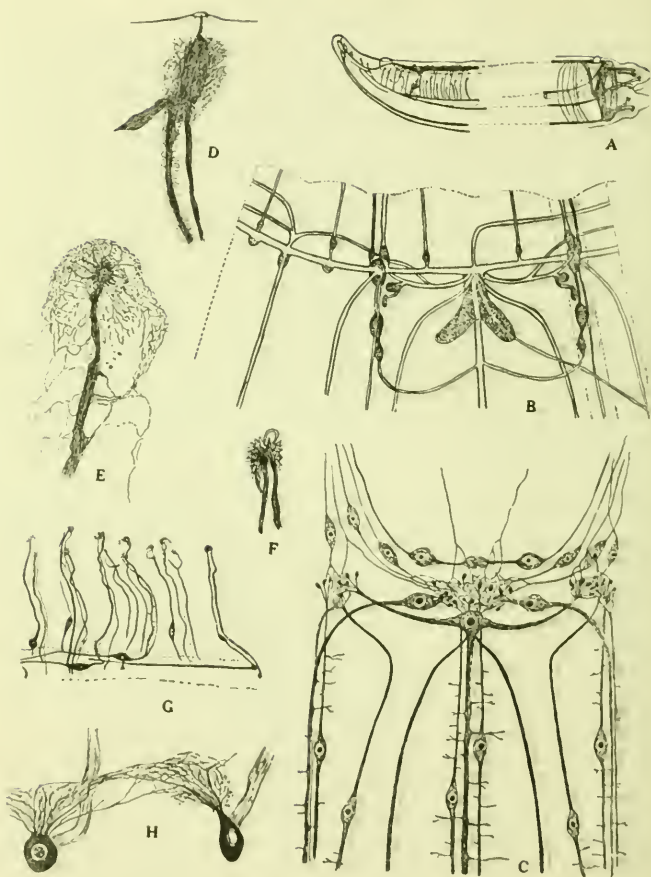


Fig. 15. A. Diagram of the nervous system of *Ascaris*, after Hesse. B. Diagram of the nervous system spread out flat, from Goldschmidt. C. Plan of the central nervous system of *Ascaris*, after Deineka. D-H. Sensory terminations and peripheral nerves of *Ascaris*, after Deineka.

a cephalic commissure. With this are associated twenty nerve cells on each lateral half and a large number just anterior to it. From these last groups six slender nerves pass forward close to the oesophagus to supply the anterior region. The two sub-ventral have small ganglia upon them. Connected with the caudal edge of the nerve ring are four chief ganglia, one dorsal, one ventral and two lateral. Each of these has long strands extending towards the tail

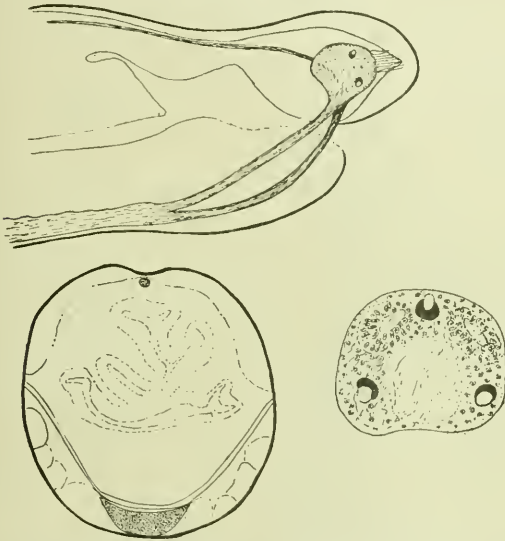


Fig. 16. The figure above is a reconstruction of the head end of *Enoplus*, showing the position of the nervous system. The lower figure at the left is of a section through the whole body of the worm, showing the dorsal and ventral nerve bands. Both these figures enlarged 75 times. The drawing at the right is from a section through the head ganglion, enlarged 170 times. The dorsal side is up in all the figures. Hilton.

end of the animal. Continued from the ventral and separated a little distance is another ventral ganglion, the post-ventral. The dorsal cephalic ganglion is the smallest; the lateral cephalic ganglia are the largest. As pointed out by others the cephalic commissure or nerve ring is essentially fibrous. The fibers are derived from the ganglia connected with it.

In the female the central anal ganglion is the largest. It connects with smaller lumbar ganglia out laterally and by a loop with the rectal ganglion.

In the male the anal ganglion is large, but the two lumbar are nearly as large. Two rings of nerves are connected with the anal ganglion and one with the small cloacal, and the other with the rectal ganglion.

GORDIOIDEA. Villott, 1874, shows that the ventral cord represents the central nervous system with an anterior and posterior

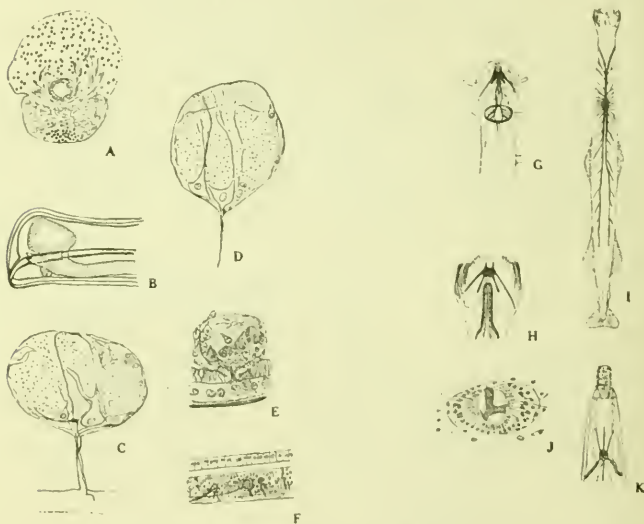


Fig. 17. A-F. Nervous system of Gordioidea. A. Section through brain and suboesophageal band, much changed from Montgomery. B. Position of supra and suboesophageal ganglion modified from Montgomery. C. and D. Sections of ventral cord. E. and F. Cross and longitudinal sections of the ventral cord after May. G and H. Head of *Chaetognatha* after Hertwig, showing brain, sense organs and chief nerves. I. Ventral ganglion shown, Hertwig. J. Eye of *Chaetognatha*. K. Ganglion in body of *Acanthocephalia* after Leuchart.

ganglion. In 1887 he traced fibers from the head ganglion into the thickened hydrodermis of the head. Vejdovsky, 1883, 1894, considers that there is no cerebral ganglion and no ganglion cells on the dorsal side of the peripharyngeal ganglion. He distinguishes neuroglia cells.

Ward, 1892, on *Nectonema*, a pelagic marine form, gives an account of the nervous system. The anterior ganglionic mass or brain forms a large portion of the floor of the anterior chamber. The oesophagus lies in a groove in its center. There is but a slight dorsal commissure above the oesophagus. The ganglion cells are not abundant in the brain. A smaller kind is more abundant than another sort which is very much larger. There are five pairs of these last which are nearly constant in position and form. The ventral nerve cord continues from the brain and runs the length of the body separated into three areas to correspond to the three nerves of which it is composed. Some large cells in the cord are much like those in the brain. In the male the ventral cord is much enlarged, being larger than the brain itself. In the female the anal ganglion is but slightly larger than the central cord with which it is connected.

Camerano, 1897, considers the nervous system to consist of a supraoesophageal ganglion and a ventral nerve strand. Montgomery, 1903, finds a ventral unpaired nerve trunk with the cephalic ganglion at its anterior enlargement and the caudal or cloacal ganglion, a posterior enlargement. To the peripheral nervous system belong the neural lamella; the endings in the hypodermis of the fibers of nerve cells situated in the central nervous system; the hypodermal longitudinal nerve; sensory cells in hypodermis; non-sensory hypodermal nerve cells and the nerve fibers which innervate the cloaca of the female and the vasa deferentia of the male. Two types of cells were found in the nerve cord. One type contained but little chromatin. These cells on the lateral sides of the cord are quite uniform and small. On the ventral side there are smaller and larger cells of this type. The larger or giant cells are less numerous. Sometimes there is a paired arrangement of these cells but usually they are irregularly placed one behind another. These cells seem to be bipolar with two large processes proceeding from the cell directed towards the fibrous core of the nerve cord. Some of the small cells appear to be bipolar or multipolar. All cells are without membranes. Montgomery thinks that these deeply staining cells are probably motor and visceral in function.

The deeply staining cells seem to be multipolar with very long processes. It could not be determined whether there was anastomosis of the processes. These cells seem like the multipolar neuroglia cells of other invertebrates but processes pass into the hypodermis.

The ventral cord seems to be made up of three converging rays of fibers but each lateral ray is made up of several distinct fiber tracts. The median tract is the largest and is made up of longitudinal fibers which are closely arranged. Very rarely are nerve

cells found on the dorsal side of this tract. They are most abundant at its ventro-lateral angles.

On each side of the median tract are three not sharply marked portions; (a) a dorsal tract mostly of deep staining fibers, (b) a latero-ventral tract bounded by a layer of clear cells, a tract mainly made up of longitudinal dark fibers, (c) a medio-ventral tract larger than the last and between it and the median. It contains dark fibers running in all directions but mainly longitudinally and also clear fibers.

The nerve cells send their fibers in radially. The "Punktsubstanz" is composed of fibers from two kinds of nerve cells.

The nerve cord has no neural sheath but is immediately surrounded by a small-celled parenchyma. Outside of the outer nerve cells of the cord is a sheet of dark staining fibers.

At intervals along the nerve cord are transverse commissures of fibers extending from the dorso-lateral angle of one side to that of the other. There is no segmental grouping of the nerve cells. The transverse commissures also are not metameric as they are too irregular and too close together.

The so-called cephalic ganglion is a slightly enlarged anterior end of the nerve cord. It is more thickened from side to side than dorso-ventrally. The nerve cells are numerous but limited to the median line. In the head the fiber tracts appear like a large median one each side of the middle line. There is a transverse commissure near where the cephalic nerves meet. As this is on the ventral side it has been called the ventral commissure. According to Montgomery there is no brain or supra-oesophageal ganglion.

The cloacal ganglion of the female is the enlarged posterior end of the ventral nerve cord just anterior to the point where the lateral lobes branch. From the ganglion there are anterior and posterior cloacal nerves.

The cloacal ganglion in the males is not so sharply limited as in the female. The length of the ganglion varies in different individuals of the same size. Small nerves pass to the vasa deferentia. The ganglion divides into a right and left caudal nerve into the caudal lobes.

In both sexes the neural lamella attach the nerve cord to the hypodermis. It is itself of hypodermal nature. At the point of the attachment of the neural lamella, the hypodermis is conical on cross section. There is a clear area here in which the longitudinal hypodermal nerve is located. It is composed of nerve fibers from dark nerve cells of the ventral cord. This hypodermal nerve runs as far as the central nervous system.

Fibers enter the hypodermis by way of the neural lamella apparently from cells in a ventral position. Upon entering the

hypodermis some run longitudinally in the hypodermal nerve or along the sides of the body.

There are two main types of sensory cells in the hypodermis, small irregular cells staining deeply and the elongated cuticular cells of the mid-ventral line. Motor cells are considered to be the clearer ones of the nervous system, the darker staining cells the sensory ones. These last run into the hypodermis.

Linstrow, 1889; Ward, 1892; and Montgomery, 1897, have found structures in the anterior part of the head which may be an eye or possibly a part of the head ganglion.

May, 1919, recognizes more clearly than Montgomery a ring of nervous tissue in the head region. In *Gordius* the brain is outlined at the first as a ring of cells in the hypoderm of the proboscis. It soon separates remaining connected only at the anterior end and ventral side. At first it consists of a few large cells which surround the larval muscles. These large cells remain in this position while the rest of the brain develops in front. The ventral cord arises as a thickening of the hypoderm, but later separates from it. The cells that make up the nerve cord at first appear as two rows of nuclei on the ventral side of the larva. The larger cells seem to be bipolar, giving off one fiber to the longitudinal tract and one to the dorsal border of the cord.

The brain of *Paragordius* develops later than that of *Gordius*. In the first genus the cells of the lamella are located in the ventral cord while in *Gordius* it consists of a series of cells. According to May the mass of cells which Montgomery calls retina is the larger part of the cephalic ganglion.

The reactions of gordioid worms is slow and of a primitive nature. The grasping reaction of the male when in contact with the female is the most definite. If a specimen is at rest it usually requires several successive stimuli to cause even a slight movement of the body. There seems to be no distinct response to light.

ACANTHOCEPHALIA. In this group the nervous system is found to be a single ganglion of large cells located on the surface of the proboscis near its base and two small ganglia in the male which supply the reproductive organs. The larger cephalic center gives off nerves to the proboscis in a cephalic direction and through the lateral retractor muscles on each side caudally strands run out to supply the body-wall. There are no sense organs known.

CHAETOGNATHA. In *Sagitta* the nervous system consists of a cerebral ganglion in which eyes are situated. A large ventral ganglion is situated about one-third or one-half of the way down the body. Oesophageal connectives join these two chief ganglia. Fibers run from the head ganglion to the jaws and sense organs of the head region and two other small ganglia have been described near the

mouth. From the large ventral ganglion many branches run to lateral and caudal regions of the body. This ventral ganglion is the chief one from the standpoint of size.

Many papillae on the surface of the body probably serve as organs of touch. The eyes, one on each side of the dorsal region of the head are globular and each contains three biconvex lenses separated by pigment and surrounded by rod-like sensory cells. About the dorsal part of the head end there is a ring-like ridge bearing modified ciliated cells. This has been called the olfactory ring.

In *Sagitta*, a great proliferation of cells in the head region of



Fig. 18. The sketch at the right is an outline of a larval *Sagitta* showing the position of the origin of the two chief ganglia and the lateral sense organs. All are indicated by the darker shaded areas. The figure at the left shows the position of the chief head ganglia of *Sagitta*.

the elongated larva forms the brain. This is added to on each side by two lateral ridges which later unite to form the cephalic hood. The ventral ganglion begins as a thickening of the ectoderm from behind the head about two-thirds of the length of the body. A tactile organ is developed from ectoderm on each side of the tail region

a little distance from its end. At a later time a double curved line of nuclei forms a horse-shoe shaped area, the so-called olfactory organ.

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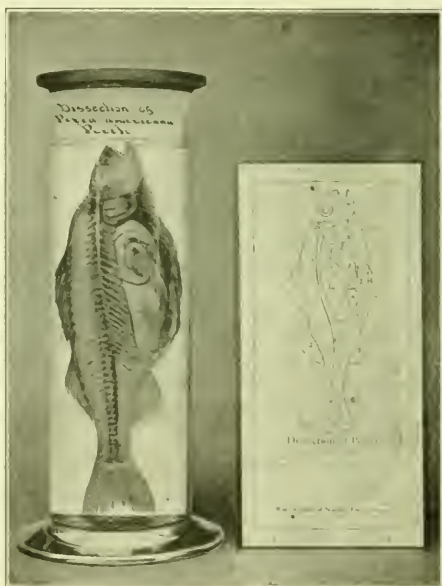
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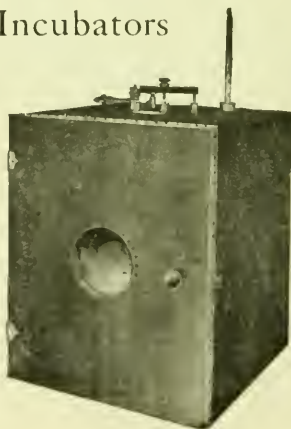
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The Biology of the North American Crane-Flies

(Tipulidae, Diptera)

VI. The Genus *Cladura* Osten Sacken

By CHARLES P. ALEXANDER

Generic Diagnosis

Larva. Form comparatively short and stout; integument provided with a delicate appressed pubescence; no distinct setae; basal annulus of each of abdominal segments two to seven with a transverse area of microscopic points arranged in long, transverse rows. Last ventral segment with a flattened lobe covered with short setae, evidently an organ for shoving. Spiracular disk entirely without lobes, the spiracles being situated on the exposed dorso-caudal surface of the last abdominal segment. Head-capsule relatively compact; frontal plate broad, only slightly narrowed behind. Labrum quadrate, with conspicuous, oval, lateral arms; antennae two-segmented, the terminal segment elongate-oval; mandibles of a herbivorous type, with an apical point and two incomplete rows of teeth on the inner or cutting face; mental bars widely separated, each bar provided with two acute teeth at its mesal end.

Pupa. Cephalic crest gibbous, entire or feebly bifid, armed on either side with a single powerful bristle; two bristles on both the front and vertex; labrum with pair of small bristles at each cephalic-lateral angle; labial lobes subquadrate, weakly separated by the apex of the labral sheath; palpal sheaths short and stout, straight; lateral margins of eye produced laterad into a digitiform lobe; antennal sheaths extending to opposite one-third the wing-sheaths. Pronotal breathing horns lacking, entirely sessile; pronotum and mesonotum armed with conspicuous bristles; wing-sheaths ending opposite the base of the third abdominal segment; leg-sheaths long, ending opposite the base of the sixth abdominal segment, the hind legs longest, the middle legs shortest. Abdominal tergites with ten strong bristles, eight being arranged in a single transverse row along the posterior margin; abdominal pleurites with four strong bristles, one on anterior ring, two near the caudal margin of the posterior ring, one ventrad of the spiracle; spiracles rudimentary, situated on segments two to seven; sternites unarmed with bristles.

Discussion of the Genus

The genus *Cladura* was erected by Osten Sacken in 1859 (Proc. Acad. Nat. Sci. Phila., p. 229). The genus includes but six

known species, with a Holarctic distribution, there being two species from eastern North America, one from western North America, and three from Japan. Of the eastern North American species, the most common and best-known is the genotype, *Cladura flavoferruginea*. The six known species of the genus are all forms that appear on the wing in late summer and in autumn.

The only reference to the immature stages of this curious genus is the brief diagnosis by the writer (The Crane-flies of New York, Part II. Biology and Phylogeny. Cornell University Agricultural Experiment Station, Memoir 38, p. 949; 1921). The genotype is common and widely distributed throughout the northeastern United States, but until the present year the writer had been unable to locate the immature stages. The conditions under which these stages occur are briefly outlined herein.

Augurville, or Brownsfield, Woods, near Urbana, Illinois, is an open, low Transitional or upper Austral woodland, traversed in spring and early summer by a small stream. In early spring the valley through which this brook flows is carpeted with a dense growth of Blue-eyed Mary (*Collinsia verna*). On the higher ground and dry slopes, other characteristic spring flowers, such as *Trillium recurvatum*, *Claytonia virginica*, squirrel-corn, dutchman's breeches, blood-root, white trout-lily, and other forms, occur in numbers. The forest cover consists of linden, hard maple, buckeye, hackberry, bur oak, honeylocust, and a few less common species, certain individuals of all of these species being giants of their kind and evidently members of the primitive forest. The undergrowth consists principally of pawpaw and spice-bush, together with considerable reproduction of buckeyes and other trees. In the autumn, the vernal flora is replaced by the dominant wood-nettle, many species of *Aster* and *Solidago*, some *Eupatorium* and other late summer plants. Adults of *Cladura flavoferruginea* were found in these woods during the fall of 1919.

On September 5, 1920, Mrs. Alexander and the writer began a systematic search for the larvae of *Cladura*. Earlier experience in Maine, New York, and Kansas had demonstrated that it was highly improbable that the early stages were to be found in mud, or even in damp earth, or in decaying wood, these habitats being those commonly frequented by the early stages of the Tipulidae. A careful search was instituted in soil that was baked comparatively hard and dry. The lumps were dug out and crumbled into dust, the contents being carefully examined. This method of search soon revealed a short, stout, light yellow crane-fly larva, that was at once determined as probably being that of *Cladura*. On this date, the only other insects associated with this larva were larvae of the Scarabaeid, *Xyloryctes satyrus* (Fabr.), a Tenebrionid, *Meracantha contracta* (Beauv.), and a few adult Corabidae and Staphy-

linidae. The conspicuous millipede *Spirobolus marginatus* (Say), was also found in these situations. The soil was covered with a layer of dead leaves and other vegetable detritus, but this had not been sufficient to prevent the dessication of the soil to a depth varying from six to twelve inches or more. Three larvae taken on September 5 were placed in breeding vials.

On September 19, 1920, Mrs. Alexander and the writer continued the search in these same haunts, and this resulted in the discovery of six additional larvae and four teneral pupae. As before, they occurred in soil that was very dry, underneath a layer of leaf-mold and other debris. These were placed in rearing.

On September 29, 1920 the writer again went to Augurville Woods. The weather was very cold and raw. By careful searching, eight pupae were discovered, some being very dark colored and evidently nearly ready to transform to the adult condition. These were placed in tin salve boxes for rearing. On the following day, two females of *Cladura flavoferruginea* emerged from two of the pupae discussed above. Other adults emerged during the following week. The remaining larvae and pupae were preserved in alcohol.

Bergroth and other writers had surmised the relationship of *Cladura* to the nearly apterous snow-fly, *Chionea* Dalman, a fact that is amply substantiated by the discovery of the larvae of the two genera. Brauer, Egger and Frauenfeld (1854) had taken gravid females of the commonest European species of *Chionea*, *C. araneoides*, and confined them in breeding jars, where they laid a large number of eggs, which hatched into stout yellow larvae that agree in many features of their organization with the larvae of *Cladura* described in this paper. Unfortunately the larvae of *Chionea* have never been carried through to the pupal condition.

The larvae of the two genera agree in their short, stout form, the obliquely truncated spiracular disk that is quite devoid of surrounding lobes, and in the general features of the head capsule. The pupa of *Cladura* is notable by the entire lack of protuberant breathing-horns, the breathing-pores being entirely sessile. The nearest approach to this condition in the Tipulidae is found in the genus *Dicranoptycha* Osten Sacken, which is likewise characteristic of unusually dry conditions in open upland woods. Other notable features of the pupa of *Cladura* are found in the very elongate leg-sheaths and the unusual development of long setae on the dorsal and pleural regions of the abdomen. The pupa is very small compared with the adult which emerges from it.

Natural Affinities

The genus *Cladura* unquestionably belongs to the tribe Eriopterini where it was placed by Osten Sacken. The discovery of the immature stages confirms the belief that this genus, as well as *Chionea* Dalman, and probably *Crypteria* Bergroth and *Ptero-*

chionea Alexander, should be isolated from the Eriopteraria where now placed and made a separate subtribe, the Chionearia or Claduraria, the former name being based on the oldest genus.

DESCRIPTION OF THE IMMATURE STAGES

Larva—Length (fully grown), 10-10.5 mm.

Diameter, 1.2 mm.

General coloration light yellow throughout.

Form comparatively short and stout. Integument provided with a delicate appressed pubescence; no distinct setae. Abdominal segments divided into a narrow basal annulus and a much broader posterior annulus, the latter being approximately two and one-half times as long as the former; the ventral surface of the basal annuli of abdominal segments two to seven with a conspicuous transverse area of microscopic points arranged in long transverse rows.

Spiracular disk entirely destitute of lobes, the spiracles being located on the obliquely truncated dorso-caudal surface of the last abdominal segment. Spiracles circular, the ring pale, the centers dark; spiracles separated from one another by a distance about equal to or a little less than the diameter of one. Ventral surface of the terminal abdominal segment with a projecting, flattened lobe that is provided with a dense brush of short, pale setae, this organ presumably being used for propelling the insect through the soil.

Head entirely retractile. Head-capsule very compact for a member of the Eriopterini. Frontal plate broad, only slightly narrowed behind, the apex obtuse or subtruncate. Labrum-epipharynx quadrate, the surface covered with short, dense hairs; on either side a stout oval arm or lobe directed cephalad, these arms connected by narrow bars, with the frame-work of the head. Mental bars entirely separate, each bar with two acute teeth on the cephalic side immediately before the apex. Antennae two-segmented, the basal segment short-cylindrical, the terminal segment elongate-oval, gradually narrowed to the obtuse apex. Mandibles relatively slender, of a herbivorous type, the teeth blunt; apical point small; two incomplete rows of flattened obtuse denticles along the inner face of the mandible, the outermost tooth of each row largest, the others gradually smaller, becoming subobsolescent; the basal teeth are very tiny, arranged in short combs; proximal caudal angle of the mandible produced into a cylindrical chitinated bar. Maxillae consisting of simple hairy lobes.

Pupa—Length, 6.7 mm.

Width, d.-s., 1.4 mm.

Depth, d.-v., 1.4 mm.

The coloration of newly transformed pupae is pale yellow. In older individuals, the thorax, head and sheaths of the appendages gradually deepen in intensity to almost black in specimens about to transform.

Cephalic crest projecting between the antennal bases as a gibbous lobe that is entire or microscopically bifid, on either side with a conspicuous erect bristle situated immediately dorsad of the base of the antenna. Vertex between the cephalic ends of the eyes with a strong bristle on either side, immediately caudad of each of which is a small tubercle. Frontal region likewise with a pair of strong bristles that are somewhat appressed against the face, directed caudad. Labral sheath with the apex rounded, very narrowly separating the labial lobes; at the base of the labrum on either side are two small bristles; sheaths of the palpi short but stout. Lateral margin of the eyes produced laterad and slightly caudad and dorsad into a conspicuous finger-like lobe. Antennal sheaths extending to about opposite one-third the length of the wing-sheath.

Pronotal breathing horns entirely lacking, the pores being sessile, lying immediately dorsad of the antennal sheaths. Pronotal scutum with two weak bristles behind the antennal sheaths; pronotal scutellum with three powerful bristles on either side near the summit. Mesonotum gibbous but unarmed with tubercles or spines. The following mesonotal bristles are evident: one on the ventral caudal angle immediately cephalad of the wing-root; a group of two, one being much smaller than the other, immediately at the wing-root; a transverse row of three strong bristles on either side, dorsad and proximad of the wing-root; two weak bristles slightly cephalad of the level of these latter three, one on either side of the median line; a strong bristle dorsad and cephalad of the pair at the wing-root. Metanotum with a strong bristle at the ventral cephalic angle. Wing-sheaths extending to opposite the base of the third abdominal segment. Leg-sheaths long, extending to opposite the base of the sixth abdominal segment; sheaths of the posterior legs longest, a little exceeding those of the fore-legs; middle legs shortest, ending immediately beyond the base of the last segment of the posterior sheaths.

Abdominal tergites and pleurites with very conspicuous bristles; sternites entirely unarmed. The distribution of the setae is as follows: On the tergites—no setae on the anterior annulus; on the posterior annulus a single transverse row of eight long bristles along the posterior margin of the segments, four on either side of the median line; cephalad of the outermost pair of these bristles and located on the anterior part of the posterior annulus is a single strong bristle on either side; on the eighth tergite there are only four bristles, arranged to form a rectangular or trapezoidal figure. On the pleurites,—each pleurite bears four very powerful bristles, one opposite the anterior annulus, one immediately ventrad of the

rudimentary spiracle, the remaining two in a transverse row on the posterior ring near the caudal margin; on the eighth pleurite there is a single bristle. On the sternites, no bristles. Terebra of the ovipositor ending almost on a common level, the tergal valves a very little longer; each tergal valve terminates in four rather weak bristles. In the male pupae, the sternal valves are slightly more tumid and project beyond the level of the tergal valves.

Nepionotype. Urbana, Illinois, September 19, 1920.

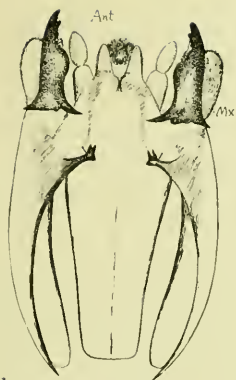
Neanotype. Urbana, Illinois, September 29, 1920.

Paratypes, larvae and pupae, September 5, 19, 29, 1920.

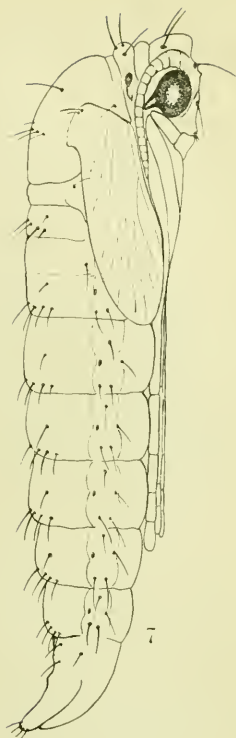
EXPLANATION OF PLATE

- Fig. 1. Head capsule of larva, ventral aspect.
- Fig. 2. Mandible
- Fig. 3. Apex of mental bar.
- Fig. 4. Antenna of larva.
- Fig. 5. Spiracular disk of larva, dorsal aspect.
- Fig. 6. Spiracular disk of larva, lateral aspect.
- Fig. 7. Pupa, lateral aspect.
- Fig. 8. Head of pupa, ventral aspect.

Ant.=Antenna; Lb.=Labium; Mx.=Maxilla; P.=Maxillary sheaths.



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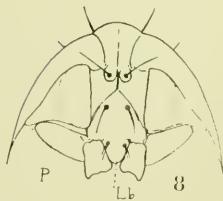
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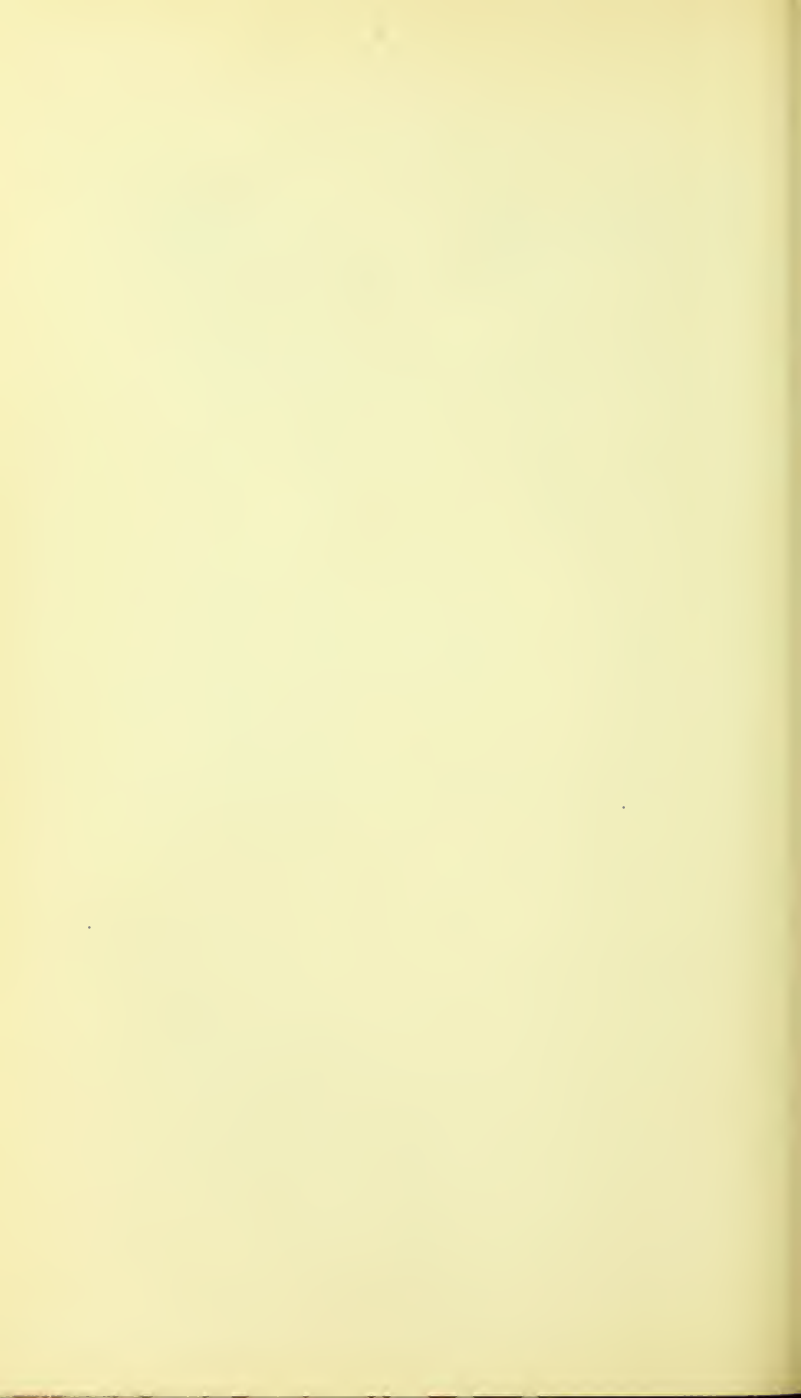
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8



A New *Platydesmoid* Diplopod from California

By RALPH V. CHAMBERLIN

From Dr. Hilton I have received an adult and several immature specimens of the interesting new genus below described. The male is not yet known.

Gosodesmus, gen. nov.

A genus differing from *Platydesmus* and *Brachycybe* in its much narrower keels, the body as a whole being slender, more as in *Dolistenus* and *Pseudodesmus*, body differing from that of the last mentioned genus in being much more depressed, the keels horizontal or, on anterior segments, upturned. Keels for the most part laterally a little thickened or margined. Dorsum of each segment with two transverse rows of large tubercles which are laterally compressed, in part cariniform, the median ones not greatly enlarged as in *Pseudodesmus*, pores not pedicillate; opening at margin. Fifth segment normal. Head as in *Brachycybe*; no eyes present.

Genotype.—*G. claremontus*, sp. nov.

Gosodesmus claremontus, sp. nov.

The dorsum of the type is fulvus, in part of a distinct reddish or pink tinge. The venter paler.

Head shaped nearly as in *Brachycybe lecontii* but somewhat narrower and the antennae a little more clavate.

Keels of first five segments bent forwards, laterally strongly rounded. Keels of sixth and seventh segments also bent forwards but with the lateral margins straight at middle, the corners, however, widely rounded. On subsequent segments the keels have the posterior corners extended a little caudad, the production becoming pronounced in the caudal region. Keels of the penult segment produced directly caudad, nearly as far as caudal margin of last tergite. Lateral margins of keels caudad of the eighth with straight portion longer, slightly indented at middle, margined. The angles on all keels remain rounded, but the posterior ones in the more caudal segments narrowly so. Caudal margin of keels toward mesal or proximal end bulging or shouldered, the caudally extending portion abutting against or a little overlapping the anterior border of the succeeding keel. First tergite with six tubercles in each row, or with one or two extra ones in an indistinct third row along anterior border. Tergites of middle region of

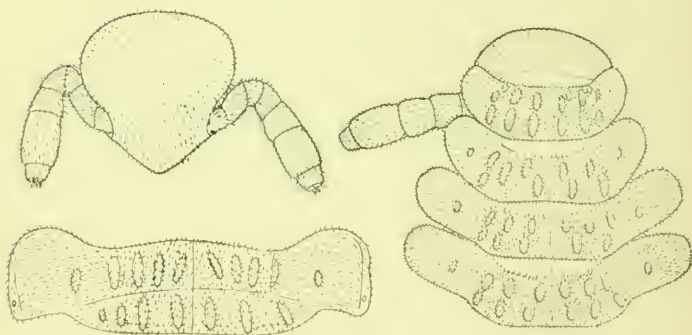
body with mostly ten tubercles in the anterior row, and six or eight in the posterior one.

Anal tergite broad, sides straight, caudal margin gently convex.

Number of segments in type (female), fifty-two.

Length, 13 mm.; width, 1.2-mm.

Locality.—California: Claremont.



Gosodesmus claremontus, sp. nov. Anterior view of head to left above, below dorsal view of seventeenth tergite. On the right, dorsal view of head and first four tergites, with right antenna omitted. x55.

Hydroids Near Laguna Beach

Arthur S. Campbell

The hydroid fauna of Laguna Beach has been little studied but there are a number of interesting forms to be found there. A few collections, made almost at random from time to time, and with no special search, form the basis of these notes.

The excellent papers by Torrey, Calkins, and Nutting have been freely consulted in making the determinations. The splendid monograph by C. C. Nutting is especially invaluable to all who may have to do with a systematic discussion of the group.

The more valuable results of this short paper are the distributional and systematic records, together with notes concerning ecological and breeding relations. More extensive studies will reveal much data not hitherto brought to light concerning the ecology, life-histories, variations, and other bionomical details of the group in this interesting locality.

KEY TO THE HYDROIDS OF LAGUNA BEACH

A. Hydranth without hydrotheca.

B. Hydranth with a basal whorl of filiform tentacles.

C. Hydranths solitary. Large. *Corymorpha palma*.

CC. Hydranths colonial.

D. Branched profusely. Medium size, often pinkish in color.

Tubularia crocea.

DD. Branched sparsely.

Tubularia sp.

BB. Hydranth with distal, knobbed tentacles.

Syncoryne mirabilis.

AA. Hydranth with hydrotheca.

B. Hydrotheca sessile. Gonangia are sporosacs.

C. Hydrotheca in two rows, usually opposite, on the stem.

D. Hydrotheca margin with two teeth.

Sertularia furcata.

DD. Hydrotheca margin smooth, tubular, adnate at base.

Sertularia tricuspidata.

CC. Hydrotheca in a single row on stem.

D. Hydrocladia on erect stems.

E. One or more intermediate internodes. Hydrotheca as deep as long.

Plumularia setacea.

EE. Septal ridges moderate, usually two in each internode.

Plumularia lagenifera.

DD. Hydrocladia modified as corbulae protecting gonotheca.

E. Median tooth straight. Nine teeth.

Aglaophenia pluma

EE. Eleven teeth, irregular.

Aglaophenia struthionides

BB. Hydrotheca stalked, bell-shaped.

C. Gonophores are sporosacs.

CC. Gonophores are medusae.

Campanularia exigua.

D. Pedicels in pairs.

Obelia gracilis.

DD. Pedicels not in pairs.

E. Pedicels on shoulders produced from stem.

Obelia geniculata.

EE. Pedicels not geniculated, branching on all sides.

Obelia commissuralis.

Sertularia desmoides Torrey and *Eudendrium ramosum* L. obtained during the summer of 1921 are not included in this key. They were determined for us by Mr. W. S. Wallace of the Hopkins Marine Station, Pacific Grove, Calif.

TUBULARIAE

CORYNIDAE: No basal whorl of tentacles, but with tentacles scattered irregularly over the hydranth. Tentacles knobbed. Hydroid branched.

Syncoryne mirabilis (Ag.) Torrey. U. C. pub. Zool. Vol. 1. 1902. p. 31.

Hydranth cylindrical. Proboscis conical. Scattering, capitate tentacles. Small. Bathymetrical range: exposed to breakers of open sea or in quiet harbours, ours on exposed pier with *O. com-*

missuralis, on live *Mytilus*. Abundant. With medusae in December, 1920.

CORYMORPHIDAE: Large, solitary hydranth with basal and distal whorls of filiform tentacles. Medusae produced just within basal tentacles.

Corymorpha palma Torrey. Hyd. Pacific Coast. U. C. pub. Zool. vol. 1, no. 1, p. 37.

A very large and beautiful species found abundantly in quiet pools. Solitary, rooted in sand by filamentous processes. Proximal tentacles 18-30 in number. Balboa Bay, in sandy pool. Usually numerous in unexposed places.

TUBULARIIDAE: Solitary or colonial. Large, often bright pink in color. Hydranths with a basal and a distal whorl of filiform tentacles. Sporosacs are pendant clusters.

Tubularia crocea (Ag.) Allman. Gym. Hyds. 1871. Dense colonies, 8-10 cms. in length. Few branches. About 20-24 basal tentacles. On piles with other hydroids, tunicates, crustacea and mollusca. Low tide, December, 1920. Long Beach, Cal.

Tubularia sp. Distinguishable from above species in several characters but not corresponding with any available descriptions. I am not inclined to think it the *T. marina* of Torrey. Growing with the above species at Long Beach. Rather rare. Probably the same species discussed by Professor Bean in the Fourth Laguna Report of Pomona College. Specimens also collected during the summer of 1921.

SERTULARIIDAE: Colony usually branching; hydrothecae sessile, forming a double row along opposite sides of hydrocaulus; gonangia large, few, no free medusae.

Sertularia furcata Trask. Proc. Calif. Acad. Sc., 1854, I, p. 112.

This is a very variable species but ours are typical and agree with figured specimens of several authors. Gonangia were numerous on colonies taken at Huntington Beach, April, 1921, from piles under the pier. Numerous, on stalks of algae and on rope.

Sertularia tricuspidata Hincks. Hist. Brit. Zoophytes. London, 1868.

This is a very common species at Laguna Beach, growing in great numbers on *Fucus* with other hydroids. Inshore tide zone. January, 1921. With a creeping rootstock on which there are a few gonangia, ripe. Hilton.

CAMPANULARIAE

PLUMULARIIDAE: Hydranths sessile, borne in a row on small lateral branches, with nematophores. Gonangia large.

Plumularia setacea (Ellis) Lamark. Anim. sans Vert., 1st ed. 1815. p. 129. Large. Nematophores, 2 above and one below hydranth. Alternate hydrocladia. Not branched.

On piles under the Pleasure Pier, Long Beach, Calif. Low tide, December 1920. Gonangia ripe, in pairs.

Plumularia lagenifera Allman. Jour. Linn. Soc. Lond., 1885, XXIX, p. 157, pl. XXVI. Very large and stiff. Unbranched. Corbula not numerous. Station unknown, probably from dredgings at Laguna Beach by Bean.

Aglaophenia struthionides (Murry) Clark. Trans. Conn. Acad., III, 1876, p. 272. Small, abundant on *Fucus* inshore, at Laguna Beach. With ripe gonangia January, 1921. Hilton. Commonest hydroid.

Aglaophenia pluma (Linn.) Lamx., Hist. Pol. Flex. 1816.

Some very typical specimens of this species were taken from near the end of the pier at Huntington Beach, California. Readily distinguishable by striking contrast in color of dark stem and lighter hydrocladia. Rather tall. With corbulae in April, 1921.

EUCOPIIDAE: Colonial, either branched or simple; hydrothecae campanulate, stalked; aperture toothed or not; gonangium large usually in axil of branch, free medusae.

Obelia commissuralis McCr. Gym. Charls. Harb., p. 95.

High, sparsely branched colonies. Hydranth deeply campanulate. Pedicels annulate throughout, alternate.

On live *Mytilus* with other hydroids. Long Beach Pier, not rare. December, 1920.

Obelia geniculata (Linn.) Schulze. Nordsee Exped. 1872, p. 129.

An abundant shore form everywhere. On *Fucus* inshore. Laguna Beach, Calif. January, 1921. No gonangia.

Obelia gracilis Calkins. Some Hydroids of Puget Sound, 1899, p. 353.

Some typical specimens were taken on stems of other hydroids from pier at Huntington Beach, California. No gonangia in April, 1921.

CAMPANULARIIDAE: Either a branched or a simple colony on which are campanulate and usually stalked hydrothecae; hypostome trumpet-shaped. Gonangium large, never with free medusae.

Campanularia exigua (Sars) Van Beneden. Rec. sur la Faune Littorale de Belgique. 1867, p. 163.

This species I am not at all certain about but my specimens seem to agree very well with descriptions and keys of both Nutting and Torrey. If the identification should prove correct the species has a much more southerly distribution than hitherto reported. Calkins reports it from Puget Sound but Torrey has not included it in his descriptions. The species is decidedly northern.

The gonangia of my specimens are a little fuller and with more pronounced opercula than that figured by Nutting, but as those of my specimens are ripe and those figured by Nutting are not this may be of little significance.

Specimens on thalli of a seaweed, probably *Macrocystis*, exact source unknown. Bottle labeled. Illingsworth, Pacific Grove, July, 1899. Many ripe gonangia.

(Contribution from the Laguna Marine Laboratory of Pomona College.)

VIII.

Rotifera, Gastrotricha and Kinorhyncha

ROTIFERS. The usual type of nervous system of the female is a dorsal ganglion or brain from which slender nerves pass to tentacles, the ciliary disc or the general body. In *Discopus*, Zelinka shows a ventral oesophageal ganglion as well as the usual dorsal one. The shape of the brain or dorsal ganglion differs somewhat in various species being almost spherical in some and quite elongate in others, and in many cases bi-lobed. In *Frullaria* several longitudinal strands of the nervous system have been shown. At nodal points ganglion cells are located. The peripheral nerves are chiefly as follows: one to each of the tentacles; a pair of lateral nerves which descend into the body and divide into two main branches, one more ventral and one lateral, which give off numerous lateral divisions to the muscles and viscera. Many fine branches run from the brain to the ciliary ring to end in intimate relation with the ciliary cells.

Antennae or feelers, usually three in number, a median dorsal and two lateral ones are supplied by definite nerves. Each of these structures consists of a small cluster of sense hairs born on a slight swelling which receives the nerve. Sometimes the antennae are retractile by means of internal muscle. These antennae may be organs for touch or smell or both.

The brains of some forms contain a sac full of mineral material. This may be some sort of sense organ, possibly a statocyst.

The eye-spot in its simplest form is a refractive globule in a red pigmented cup to which latter nerve fibers pass, or the eye or eyes may rest directly on the brain. Sometimes two eyes occur and these may be very close together, almost like one. In some species the eyes are just under the ciliary band or within the disc. A median and two lateral eyes occur in some forms, or even another pair of eyes may also be found. In some, pigment spots occur at the hind end of the body.

It has been suggested that some rotifers are able to avoid objects by means of a sense of sight aided by the tactile and olfactory sense.

The chief work on the nervous system of this group has been by Zelinka, 1888-90, Gast, 1900, and Halva, 1905. The more recent work of Hirschfelder, 1910, has added quite a little to our knowledge of the nervous system and sense organs in a number of forms. This last author recognizes four general types of nerve cells which grade into each other to some degree. Nerve fibers are described as containing a central core of fibrils, an intermediate covering and an outer sheath. Cells are uni- or bi-polar; the last kind has one

process passing to the periphery, the other running centrally. The number, position, size and form of the cells is symmetrical in both halves of the ganglion, also the processes are symmetrically disposed. Commissural fibers bind right and left halves of the ganglion. Some fibers leave the brain directly from ganglion cells while others enter or leave by way of paired nerve fibers which connect directly with the central fibrous core of the ganglion.

The ganglion cells are said to be absolutely constant as to their position, form and relative size. The position of the nuclei in the cytoplasm is not so constant. The larger and smaller fibers seem also constant in number and position.

Sense cells are found at the surface of the body more or less removed from the surface. Single sensory nerve cells with two nuclei end directly in the surface. Another kind of sensory ending



A. *Rhizotida*, front and profile, showing position of the nervous system. Zelinka.

B. Embryonic stage of a rotifer showing position of nervous system in two dark masses. Zelinka.

C. *Frullaria*, showing position of nerve strands in the body.

D. Position of nervous system in rotifer after Delage et Herouard.

E. Nervous system of *Floscularia* after Hudson and Gosse.

F. *Discopus*, showing nervous system, after Zelinka.

G. Sense organs with nerves from the brain shown in cross section after D. & H.

H. Nervous system of *Echinoderes* from several sources.

I. Nervous system of *Echinoderes* from above. Schepotieff, but much changed.

J. K. Head end of *Chaetonotus* from below J. and above K. showing brain and sense hairs. Zelinka.

is found in the tentacles where there is a combination of sensory cells at the base of the sense organ.

The retrocerebral apparatus in *Eosphora* consists of two glands lying back of the brain. They are covered with membrane and so not in direct connection with the brain. One of these glands is the pear-shaped retrocerebral sac which is clear with vacuoles. If this is in any way a sense organ it is a question what its function would be.

In *Eosphora* there is a single eye on the surface of the brain and two slightly pigmented knobs at the anterior margin of the animal; these have a direct connection with the brain and must be sense organs, possibly something like eye spots.

GASTROTRICHA. In 1864 Gosse described a knob on the oesophagus as the brain in *Chaetonotus*. Ludwig in 1875 described the nervous system on the side of the brain. Butschli, 1876, added nothing of importance and Fernald, 1890, did not see the brain in *Chaetonotus*. The clearest recognition of the nervous system was by Zelinka in 1890. A large brain in the head region surrounds the gullet above and on the sides and a pair of nerve trunks extend down the body. Cephalic sense hairs are directly connected with nerve cells of the brain. The hairs of the body may be for touch or possibly smell or taste. Simple eyes have been described for a number of species in the back part of the head, as small red spots, but not all species possess them.

KINORHYNCHA. Claparede in 1863 describes a nervous system in this group and others at an early time also figure or describe something of the nervous system. Reinhard, 1887, believes that in most cases the nervous system was not seen by the earlier investigators. He describes and figures a ganglion on the oesophagus but gives no details. Zelinka, 1894, describes a circum-oral ring and a long ventral nerve strand. Schepotieff, 1907, describes a brain above the oesophagus with two connectives and a ventral strand. The nervous system is somewhat like that of Gastrotrichia with a large upper brain of a large mass of three general parts all fused. The ventral strand runs the length of the body but is not differentiated into ganglia but has cells along its course. Eye spots have been described in some species, the number being from 2-8.

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A Catalog of the California Aleyrodidae and the Descriptions of Four New Species

By DONALD D. PENNY

Introduction

This paper consists of a list of the already described species of Aleyrodidae, or white flies, taken from the State of California, and a record of their food plants and localities together with the descriptions of four new species.

The writer has not attempted to give a systematic arrangement of the family in this paper but has laid much stress on the completeness of the list of food plants upon which the different species have been taken in order that from a knowledge of the food plants the family will be more readily accessible and at the same time may be kept up to date in respect to the host records.

In the collecting of specimens the writer has not been confined to any one section of the state but has taken and received specimens from a wide range of localities, including sections of both high and low elevation, from the extreme north to the extreme south of the state. This has resulted in the recording of some new hosts for the already described species as well as the finding of the four new species herein described.

The writer desires to thank Professor E. O. Essig for the many specimens given and other kind assistance rendered during the preparation of this paper.

Paratypes of the author's new species have been deposited with the collection of the California Academy of Sciences, Golden Gate Park, San Francisco, California.

Dialeurodes citri (Riley and Howard)

(*Aleyrodcs citri* Riley and Howard)

Syn.: *aurantii* Maskell

1893—Insect Life, vol. 5, p. 219.

Food Plants.—*Ailanthus glandulosa*, *Allamanda neriifolia*, *Ampelopsis tricuspidata*, *Cera us* sp., *Choisya ternata*, *Citrus* spp., *Coffea arabica*, *Diospyros kaki*, *Diospyros virginiana*, *Ficus macrophylla*, *Fraxinus lanccolata*, *Gardenia florida*, *Gardenia jasminoides*, *Hedera helix*, *Jasminum fruticans*, *Jasminum odoratissimum*, *Ligustrum amurense*, *Ligustrum* sp., *Maclura aurantiaca*, *Melia azedarach*, *Melia azedarach* var. *umbraculiformis*, *Myrtus communis*, *Magnolia fuscata*, *Myrtus lagerstroemia*, *Osmanthus amer-*

icanus, *Prunus caroliniana*, *Prunus laurocerasus*, *Punica granatum*, *Pyrus* sp., *Quercus aquatica*, *Smilax* sp., *Syringa vulgaris*, *Tecoma radicans*, *Viburnum tinus*, *Xanthoxylum clava-herculis*.

Localities.—At present this species is known to exist in the cities of Sacramento and Marysville. Also occurs in the Southern States—North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas.

Dialeurodes citrifolii (Morgan)

(*Aleyrodes citrifolii* Morgan)

Syn.: *nubifera* Berger

1910—E. W. Berger—Bull. 103, Fla. Agr. Exp. Sta. (*A. nubifera*).

Food Plants.—*Citrus* spp.

Localities.—Not in California at the present time, having been once exterminated at Bakersfield. Also recorded from Mississippi, North Carolina, Louisiana, Florida, Cuba, China, Japan and India.

Aleuroplatus coronatus (Quaintance)

(*Aleyrodes coronata* Quaintance)

1900—A. L. Quaintance, Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 22-23. Orig. desc.

Food Plants.—*Arbutus menziesii*, *Castanea* sp., *Heteromces arbutifolia*, *Quercus agrifolia*, *Quercus chrysolepis*, *Quercus densiflora*. Collected by the writer on *Rhamnus californica* at Collins Springs, May 1917.

Localities.—Alameda County, Collins Springs, Golden Gate Park, King's Mountain, Los Angeles, Mendocino County, Pomona, San Bernardino, Santa Catalina Islands, Santa Clara Valley, Santa Cruz Range, San Ramon Valley, Santa Rosa, San Jacinto, Sierra Morena Range, Yosemite Valley.

Aleuroplatus gelatinosus (Cockerell)

(*Aleyrodes gelatinosus* Cockerell)

1898—T. D. A. Cockerell, Can. Entom. Vol. 30, p. 264. Orig. desc.

Food Plants.—*Quercus agrifolia*, *Quercus arizonica*. Collected by the writer on *Rhamnus californica* at Collins Springs, May 1917.

Localities.—Collins Springs. Collected by E. O. Essig at Auburn and Placerville. Also occurs in Arizona (type locality).

Pealius kelloggi (Bemis)
(*Aleyrodes kelloggi* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., Vol. 27, p. 499. Orig. desc.

Food Plants.—*Prunus ilicifolia*, *Quercus agrifolia*. Collected by E. O. Essig on Catalina cherry, Pasadena, Dec. 1914. Also Niles.

Localities.—Niles, Pasadena, Santa Clara County, Sierra Morena Range.

Pealius maskelli (Bemis)
(*Aleyrodes maskelli* Bemis)

1904.—Proc. U. S. Nat. Mus., vol. 27, p. 524. Orig. desc.

Food Plant.—*Quercus densiflora*.

Localities.—King's Mountain, La Honda.

Bemisia inconspicua (Quaintance)
(*Aleurodes inconspicua* Quaintance)

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Ent. U. S. D. A., pp. 28-29. Orig. desc.

Food Plants.—*Arbutus menziesii*, *Clematis ligusticifolia*, *Heteromeles arbutifolia*, okra, *Physalis* sp., *Quercus agrifolia*, *Quercus densiflora*, *Rhamnus californica*, *Rhamnus crocea*, sweet potato, *Umbellularia californica*. Collected by the writer on *Acer macrophyllum*, Los Gatos, October 1916.

Localities.—Haywards, Los Gatos, Santa Cruz and Sierra Morena mountains. Also recorded by Quaintance from Florida.

Aleyrodes amnicola Bemis

1904—Proc. U. S. Nat. Mus., vol. 27, p. 514. Orig. desc.

Food Plants.—*Salix laevigata*, *Washingtonia nuda*.

Localities.—Stevens Creek.

Aleyrodes essigi, new species

Larva:—Color pale yellow with orange colored visceral glands in abdominal region; shape flat, elliptical, broadest in the abdominal region. The dorsum is free from wax but there is a lateral fringe of coalesced, white, wax rods. Segments of the case distinct. Marginal crenulations well rounded and incisions deep. Cephalic margin with a pair of short, delicate setae; caudal margin with long caudal setae set in tubercled bases; latero-caudal margins with a pair of small setae and a similar pair just within the latero-caudal margins.

Pupa-case:—Size 0.92 mm. by 0.53 mm.; shape elliptical; color transparent white with developing adult within light yellow. There is a vertical ventral fringe of closely coalesced, white, wax rods extending to the leaf. This fringe may be seen adhering to the leaf in the form of a ring when the case is removed. Secretions of the dorsum are lacking. The segments of the dorsum are distinct. The abdomen bears two parallel rows of irregular depressions which are indistinct in some cases. Vasiform orifice subsemielliptical with the cephalic margin straight. Operculum subrectangular, curved laterally, the distal end truncate extending one-half the length of the orifice. Lingula cylindrical extending about seven-eighths of the length of the orifice, densely setose at its distal end which bears a pair of small lobes and a pair of long, straight setae projecting caudad. There are other setae on the

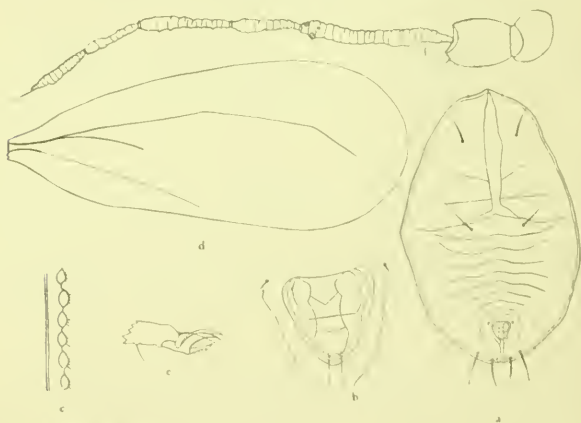


Fig. 1. *Alepodes essigi* n. sp. a, pupa-case; b, vasiform orifice; c, anterior margin of the forewing; d, forewing; e, claw of the adult; f, antenna of the adult.

case as follows: a small, delicate pair on the cephalic margin, a long pair in the cephalic region, an equally long pair on the first abdominal segment, a minute pair opposite the lateral extremities of the cephalic margin of the vasiform orifice, a long pair set in tubercled bases just within the caudal margin and a very small pair on the latero-caudal margin. The case must be handled carefully in mounting to prevent breaking these setae. The sub-marginal area is not set off from the dorsum by a raised ridge or depression. The margin of the case is evenly crenulated, the

incisions shallow except at the caudal margin where they become deeper and the wax tubes longer and narrower. The thoracic tracheal folds are not evident.

Adult female:—Length 1.2 mm.; general color light yellow with head and thorax darker than abdomen. Legs and mentum dusky. Paronychium blade-like; wings immaculate. Forewing length 1.2 mm., width 0.40 mm. Radial sector, media and cubitus present; radial sector with two flexures. Media short; cubitus a faint line except at the base. Antennae dusky; average lengths of segments as follows: segment 1, 0.024 mm., segment 2, 0.158 mm., segment 3, 0.109 mm., segment 4, 0.062 mm., segment 5, 0.072, segment 6, 0.044 mm., segment 7, 0.056 mm. Eyes very dark red, constricted but not divided.

This species was collected by Professor E. O. Essig, for whom the species is named, on *Ulmus* sp. at Mission San Jose, September 1916.

Alcyrodes pruinosa Bemis

1904—Proc. U. S. Nat. Mus., vol. 27, p. 491.

Food Plant.—*Heteromeles arbutifolia*.

Localities.—Berkeley, Catalina Islands, Leland Stanford Jr. University.

Aleyrodes spiraeoides Quaintance

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 36-38. Orig. desc.

Food Plants.—*Aesculus californica*, *Convolvulus sepium*, *Lonicera involucrata*, *Nicotiana glauca*, *Opulaster capitatus*, *Plantago major*, *Sonchus oleraceus*, *Solanum douglasii*, *Troximon* sp. Collected by the writer on *Asclepias* sp., at Berkeley, October 1916 and in Santa Cruz County, November 1920; *Ceanothus* sp., Los Gatos, December 1917; *Hypericum androsamum* on the University of California Campus, November 1916; *Melaleuca hypericifolia* on the University of California Campus, November 1916 and on Pentastamen at Capitola, December 1917.

Localities.—Alameda, Berkeley, Los Angeles, Los Gatos, Santa Cruz County.

Alcurotulus nephrolepidis (Quaintance)

Syn.: *extraniens* Bemis

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 29-30. Orig. desc.

Food Plants.—*Acrostichum capense*, *nephrolepis*.

Localities.—Conservatories of San Francisco. Type locality, Pennsylvania.

Aleurothrixus interrogationis (Bemis)*(Aleyrodes interrogationis* (Bemis)

1904—Bemis, Proc. U. S. Nat. Mus., vol. 27, p. 516.

Food Plant.—*Ceanothus californicus*.

Localities.—Black and King's mountains, Pacific Congress Springs.

Aleuroparadoxus iridescens (Bemis)*(Aleyrodes iridescens* Bemis)

1904—Bemis, Proc. U. S. Nat. Mus., vol. 27, p. 487. Orig. desc.

Food Plants.—*Arctostaphylos manzanita*, *Heteromeles arbutifolia*, *Rhamnus californica*, *Rhamnus crocea*, *Umbellularia californica*. Collected by the writer on *Salvia* sp., San Diego County, May 1917.

Localities.—King's Mountain, Yosemite Valley, San Diego County, San Gabriel Mountains, Santa Clara Valley, Santa Cruz Mountains.

Asterochiton corollis, new species

Pupa-case:—Size 0.90 mm. by 0.61 mm.; shape elliptical with the caudal end truncate; color dark brown. The wax secretion of the dorsum, as observed from somewhat imperfect specimens, consists of three separate systems as follows; first, a continuous marginal fringe extending entirely around the case, the rods of which are short and loosely joined, projecting directly toward the leaf to about one-half of the distance from the margin to the leaf. Second, a series extending continuously around the case just within the margin. The rods of this system are long, white and closely coalesced at their bases and extend upward for the greater part of their lengths then outward over the case, separating into ribbon-like structures at their extremities. Third, a series of short, thick rods arranged in groups which arise mesad of the second system and which project toward the center of the case. In addition to the dorsal wax the pupa case secretes a high vertical fringe of wax on which the case rests. The submarginal area bears a row of large, conical, papilla-like pores the bases of which are close together, the pores themselves measuring about 0.02 mm. in length. These pores undoubtedly secrete the long ribbon-like wax structure. On the dorsum proper are irregularly shaped, conspicuous, pore-like openings which are arranged in groups, the outer margins of which conform to the general curve of the case. These groups are found as follows: two in the cephalic region consisting of fourteen pores each, two in the thoracic region containing about twelve openings each and two in the abdominal region containing twenty-four each. Scattered through these pores are numerous very small circular pores also two pair of similar circular pores

in the cephalic region close to the median line, two pair on each segment of the thorax, two pair each on segments 1 and 2 of the abdomen, one pair each on segment 3, 4, 5 and 6 and three pair on segment 7 of the abdomen. In the submarginal area between the papilla-like pores and the margin is a row of the small circular pores and in addition to these some may be found with no apparent regularity near the bases of the submarginal papilla pores. The sutures of the case are distinct, the last three of the abdomen strongly reflexed caudad. The crenulations of the margin are broad and the incisions shallow. The submarginal area is not set off by a raised ridge or depression. Vasiform orifice subcordate, with the anterior margin straight, the lateral margins with corrugations or folds extending inward and downward; operculum shaped similar to that of the orifice with the caudal end slightly truncate, one-half filling the orifice; lingula subspatulate, densely setose, extending about three-fourths of the length of the orifice, bearing at its distal extremity three pair of lateral lobes and a pair of terminal lobes. Thoracic tracheal folds not evident. Just laterad of the anterior margin of the vasiform orifice is a pair of

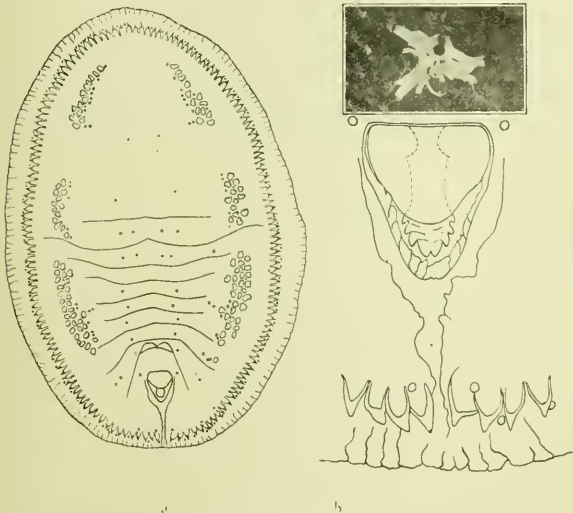


Fig. 2. *Asterochiton corollis* n. sp. a, pupa-case; b, vasiform orifice, caudal furrow and section of the caudal margin; c, pupa-case showing the wax secretions.

fine, delicate hairs set in circular bases. Delicate latero-caudal marginal hairs are present but cephalo-marginal hairs and caudal spines are lacking.

Adults unknown.

This species was described from three specimens of the pupa taken by the writer on *Arctostaphylos mauzanita* at Pine Hills, San Diego County, May 1917.

Locality.—Pine Hills. (type)

Asterochiton diasemus (Bemis)

(*Aleyrodes diasemus* Bemis)

1904—Bemis, Proc. U. S. Nat. Mus. vol. 27, p. 516. Orig. desc.

Food Plants.—*Ribes glutinosum*, *Symphoricarpos racemosus*.

Localities.—Alameda, King's Mountain, Leland Stanford Junior University, Menlo Park, San Francisquito Creek.

Asterochiton dimiutis, new species

Pupa case:—Size 0.53 mm. by 0.33 mm., shape elliptical, very convex, extending high above the leaf particularly in the cephalic region the ventral surface of which is projected into a blunt point. Color smoky white, parasitized specimens very dark brown. The wax secretion of the dorsum consists of an irregular row of tapering, glassy, white, waxen rods arising in the submarginal area and which extend upward and outward over the margin of the case and are about as long as one-third the width of the case; also



Fig. 3. *Asterochiton dimiutis* n. sp. a, pupa-case; b, side view of the pupa-case; c, vasiform orifice and section of the caudal margin; d, forewing of the adult; e, anterior margin of the forewing; f, claw of the adult; g, first three segments of the antenna of the adult; h, male genitalia.

a pair of similar waxen rods arising in the cephalic region and extending upward over the case, a pair each on two segments of the thorax and on segments 3, 4, 5 and 6 of the abdomen. In addition to the dorsal secretion the case bears a continuous high, vertical fringe of coalesced, white, wax rods which extend from the margin of the case to the leaf. This wax functions as a support for the case and it remains firmly attached to the leaf when the case is removed. The pores which give rise to the dorsal wax secretion are large, 0.012 mm. in length, conical in shape and are arranged in a rather irregular submarginal row of about sixty in number; also a pair of similar pores in the cephalic region, a pair each on the two segments of the thorax and a pair each on segments 3, 4, 5 and 6 of the abdomen. Between the bases of the submarginal wax pores may be found very small circular pores, a row of similar circular pores between these and the margin of the case, and along the dorso-meson from the cephalic region to the vasiform orifice a pair for each segment, though occasionally missing on some segments. Segments of the dorsum are distinct and in the abdominal region the sutures are strongly bent caudad. Vasiform orifice subcordate, length 0.06 mm., anterior margin straight, inner lateral margins with corrugations extending downward. Operculum subsemielliptical, about one-half filling the orifice. Lingula slightly hidden, subspatulate, densely setose, projecting slightly beyond the orifice and bearing at its distal extremity a pair of terminal and three pair of lateral lobes. Submarginal area not set off from the dorsum by a raised ridge or depression. Thoracic tracheal folds not visible. Conspicuous caudal spines present, arising just within the caudal margin, but cephalo-marginal and latero-caudal marginal spines absent.

Adult female:—Length 1.0 mm., general color yellow to orange, eyes very dark brown, constricted but not divided. Forewing length 1.15 mm., radial sector, media and cubitus present. The radial sector is the main vein of the wing extending through the central area. The media is reduced to a remnant, being very short and faint and arising as a branch of the radial sector. The cubitus appears as a cleared line arising independently of the radial sector and projecting caudad toward the margin then paralleling it for a very short distance before ending. The portion of the wing through which the cubitus passes is very slightly dusky or unclear thus making the cleared vein more distinct.* Length of antennae segments from segment 1 to segment 7 inclusive, as follows: 0.024 mm., 0.052 mm., 0.128 mm., 0.048 mm., 0.064 mm., 0.044 mm., 0.040 mm. Paronychium blade-like.

This species was described from an abundance of pupae and several adults taken by the writer on tarweed (*Chamaebatia*

*This type of vein is spoken of by Bemis (Proceedings of the U. S. Nat. Museum, vol. 27, page 493) as a long, oblique, anal fold.

foliolosa) at Placerville, May, 1918. The pupae occur on both sides of the leaves but the very small size of the pupa case together with the numerous minute leaflets on which the case rests make it exceedingly difficult to observe with the naked eye.

Locality.—Placerville. (type)

Asterochiton glacialis (Bemis)

(*Alcyrodes glacialis* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 518. Orig. desc.

Food Plants.—*Ceanothus californicus*, *Clematis ligusticifolia*, *Opulaster capitatus*, *Quercus densiflora*, *Rhamnus californica*, *Rubus vitifolius*, *Symphoricarpos racemosus*. Taken by the writer on a *Salvia* hybrid on the University of California campus, November 1916.

Localities.—Alameda, Berkeley, King's Mountain, Santa Clara Valley, Santa Cruz and Santa Morena ranges.

Asterochiton hutchingsi (Bemis)

(*Alcyrodes hutchingsi* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 532. Orig. desc.

Food Plant.—*Arctostaphylos* sp.

Locality.—Yosemite Valley.

Asterochiton madroni (Bemis)

(*Alcyrodes madroni* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 507. Orig. desc.

Food Plant.—*Arbutus menziesii*.

Localities.—King's Mountain. Collected by the writer at Berkeley, Los Gatos, Santa Cruz County.

Asterochiton merlini (Bemis)

(*Alcyrodes merlini* (Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 512. Orig. desc.

Food Plants.—*Arbutus menziesii*. Collected on *Arctostaphylos* spp. by E. H. Davis in San Diego County and by the writer on *Arctostaphylos* sp. at Colfax, April 1920.

Localities.—Auburn, Colfax, King's Mountain, Placerville, San Diego County. (Throughout Sierra Nevada Mountains.)

Asterochiton tentaculatus (Bemis)

(*Alcyrodes tentaculatus* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 494. Orig. desc.

Food Plants.—*Clematis ligusticifolia*, *Lonicera involucrata*, *Opulaster capitatus*, *Quercus agrifolia*, *Quercus densiflora*, *Rhus diversifolia*.

Locality.—Alameda.

Asterochiton vaporariorum (Westwood)
(*Aleyrodes vaporariorum* Westwood)

Syn.: *nicotianae* Maskell

Syn.: *papillifer* Maskell

Syn.: *lecanioides* Maskell

1856—Westwood, Gard. Chron., p. 852. Orig. desc.

Food Plants.—*Ageratum*, *Aphelandra*, *Aster*, bean, *Begonia*, *Bignonia*, *Capsicum*, *Chrysanthemum*, *Citrullus vulgaris*, *Coleus*, *Cucumis melo*, *Cucumis sativus*, *Fragaria* sp., *Geranium*, *Gonolobus*, *Lactuca sativa*, *Lantana commara*, *Nicotiana*, *Oxalis*, *Pelargonium*, *Persea gratissima*, *Primula vulgaris*, *Rosa* sp., *Rubus*, *Salvia splendens*, *Solanum melongina*, *Solanum pseudo-capsicum*, *Tecoma*, *Vitis*. Collected by the writer on *Abutilon* sp., Santa Cruz county, July 1917; on *Aralia cordata*, October 1916, *Datura sanguinata*, November 1916, *Helianthus californicus*, November 1916, *Eupatorium ruparium*, November 1916 on the University of California Campus; on *Quercus kelloggi*, Santa Cruz county, June 1919, on *Rhamnus californica*, Los Gatos, November 1916 and on *Rhus diversiloba*, Santa Cruz county, September 1918.

Localities.—Berkeley, Los Gatos, Santa Cruz County, Santa Rosa.

Asterochiton vittatus (Quaintance)
(*Aleurodes vittata* Quaintance)

1900—A. L. Quaintance, Tech. Ser. No. 8, Bur. Entom. U. S. D. A., p. 42, Orig. desc.

Food Plant.—Chapparal.

Localities.—Claremont, Ontario, Pomona.

Asterochiton wellmanae (Bemis)
(*Aleyrodes wellmanae* Bemis)

1904—Bemis, Proc. U. S. Nat. Mus. vol. 27, p. 525. Orig. desc.

Food Plant.—*Rhamnus californica*.

Localities.—Leland Stanford Junior University, Stevens Creek.

Tetraleurodes acaciae (Quaintance)
(*Aleyrodes acaciae* Quaintance)

1900—A. L. Quaintance, Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 19-20. Orig. desc.

Food Plants.—*Acacia*, *Bensera microphylla*, *Rhamnus californica*.

Localities.—Fullerton, Los Angeles, Ontario. Also recorded from Lower California and Mexico.

Tetraleurodes dorseyi (Kirkaldy)*(Aleyrodes dorseyi* Kirkaldy)Syn.: *quaintancei* Bemis

1907—Kirkaldy. Bul. 2 Div. Ent. Bd. Comm. Agr. & Forestry, Hawaii, p 52.

Food Plant.—*Rhamnus crocea*.

Locality.—Stevens Creek.

Tetraleurodes errans (Bemis)*(Aleyrodes errans* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 500. Orig. desc.

Food Plants.—*Arbutus menziesii*, *Umbellularia californica*. Collected by the writer on *Aesculus californica*, University of California Campus, September 1916.

Localities.—Berkeley, King's Mountain, Leland Stanford Junior University, San Ramon Creek, Santa Clara Valley, Santa Cruz Mountains, Redwood creek, Usal.

Tetraleurodes herberti, new species

Pupa-case:—Average size 0.92 mm. by 0.64 mm.; shape sub-elliptical, slightly more pointed at the caudal end; color shining black. The case is closely applied to the leaf. Dorsum keeled along the median line with the raised area somewhat wider in the cephalic and thoracic regions than in the abdominal region. The segments are distinct with suture lines well defined, particularly across the keeled area. Outlines of rudimentary legs on the ventral surface plainly visible through the case. In the cephalic region on both sides of the median line is a circular mark or depression which is bounded by two markings arranged as arcs of concentric circles. Caudad of these markings and close to the median line on either side is another group of two subcircular, clearly defined markings or pore-like openings, one latero-caudad of the other. In the thoracic region is still another pair of triangularly arranged groups of three irregularly outlined depressions, a pair on each segment suture from the thoraco abdominal suture to the vasiform orifice. In the cephalic and thoracic region on either side of the median line is a row of about five small circular pores which passes just laterad of the groups of markings in those regions to and including the first abdominal segment. Smaller circular pores are present just caudad of the abdominal depressions, one for each depression. A pair of similar pores are found just cephalo-laterad of the anterior margin of the vasiform orifice, another pair laterad and still another pair just cephalad of the anterior margin of the vasiform orifice. Vasiform orifice sub-ovate, surrounded by thickened integument and raised well above the general level of the dorsum; operculum filling the opening.

Lingula partially obscured, spatulate, distal end spherical and densely setose. The submarginal area bears a continuous row of conspicuous circular pores which are about 0.014 mm. in diameter and which project somewhat from the case. The submarginal area is set off from the dorsum proper by a raised ridge which is continuous around the case save in the cephalic region. The crenulations of the margin are broad and well rounded, the incisions shallow. Marginal wax tubes project mesad about one-third the width of the margin. Thoracic tracheal folds not evident. A pair of fine, delicate caudal spines are present just within the caudal margin, set in tubercled bases. On the suture lines extending cephalad from the vasiform orifice is a pair of very fine delicate hairs set in circular bases. Cephalo-lateral and caudo-lateral marginal spines are lacking.

Adult:—Length about 0.65 mm.; color yellow with the head and thorax lighter. Eyes dark red, constricted but not divided. Wings immaculate, forewing with Radius 1, cubitus and media present; media short, faint and poorly defined. Paronychium blade-like. The antennae of all specimens were broken.

Described from material taken by F. W. Herbert, for whom the species is named, at Pleasanton, Alameda County, October 1918,

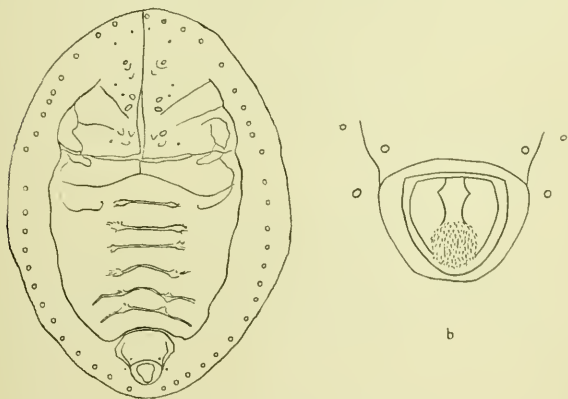


Fig. 4. *Tetratreurodes herbeti* n. sp. a, pupa-case; b, vasiform orifice.

on black locust. The specimens consisted of pupae with only three adults which were badly damaged. The pupae were attached to both sides of the leaf.

Localities.—Pleasanton. (type)

Tetracurodes melanops (Cockerell)

(*Aleyrodes melanops* Cockerell)

1903—Cockerell. Bul. 67, Fla. Agr. Expt. Sta. p. 665.

Food Plant.—*Quercus* sp.

Localities.—Alpine Tavern, Mt. Lowe.

Tetracurodes nigrans (Bemis)

(*Aleyrodes nigrans* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 522.

Food Plants.—*Arbutus menziesii*, *Arctostaphylos manzanita*, *Ceanothus californicus*, *Clematis ligusticifolia*, *Eriodictyon californicum*, *Heteromeles arbutifolia*, *Lonicera involucrata*, *Prunus ilicifolia*, *Rhamnus californica*, *Symphoricarpos racemosus*, *Umbellularia californica*. Collected by the writer on *Salvia* sp., Corona, May 1917.

Localities.—Corona, Black and Kings Mountains, Pacific Congress Springs, San Ramon Valley, Santa Clara Valley, Santa Cruz Range, slopes of Sierra Morena Range, Stevens Creek.

Tetracurodes perileuca (Cockerell)

(*Aleyrodes perileucus* Cockerell)

1903—Cockerell. Bul. 67, Fla. Agr. Exp. Sta., p. 664.

Food Plant.—*Quercus* sp.

Localities.—La Jolla.

Tetracurodes splendens (Bemis)

(*Aleyrodes splendens* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 489.

Food Plants.—*Rhamnus californica*, *Arctostaphylos* sp.

Localities.—Leland Stanford Junior University, Yosemite Valley.

Tetracurodes stanfordi (Bemis)

(*Aleyrodes stanfordi* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 508.

Food Plants.—*Quercus agrifolia*, *Quercus densiflora*. Collected by the writer on *Rhamnus* sp., Fresno, May 1917.

Localities.—Big River, Mendocino County, Black Mountain, Fresno, King's Mountain, Santa Clara Valley.

References:—The writer has made use of all available works dealing with the descriptions of the species of the family of Aleyrodidae and especially the following:

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Preliminary Notes on Growth-Stages in Brittle-Stars

Arthur S. Campbell

There are a number of conditions to account for our present lack of a rational system of the brittle-stars. One of the principal reasons why the group is so difficult to classify lies in the profound ignorance of their growth-changes. The excellent systematic work of Ljungman, Lutkin, Lyman, Koehler and the two Clarks have brought some thousand species to attention but the real relationship of these as larger groups is yet quite unsolved. There have been several attempts to rationalize the classification, one by Bell, 1892, and more recently by Matsumoto, 1915. Neither of these systems is thoroughly based upon phylogenetic history, and hence, cannot be conclusive since the state of our present knowledge is such as to forbid any sweeping generalizations.

Although the chief reason for our lack of a rational system in the group is this lack of attention upon growth-stages, another lies in the general disregard of palaeontological evidence, and a further reason because attention has been focused upon larval, rather than post-larval, stages.

Material heretofore studied in connection with this problem of growth-stages in the young of ophiurans numbers less than one dozen species, all of which are Atlantic or West Indian forms. My own observations were made upon seven species, the members of five families. All are the members of the littoral fauna of Southern California. Specimens were collected in all accessible habitats and studied after preservation.

The excellent plates for this paper are the work of Miss E. Keyes, a student in Pomona College.

It is not always possible to tell just why one places a form in this or that group for many characters are subtle and one is obliged to depend very often upon general features. Especially is one dependent upon as complete a series as possible in placing a juvenile. H. L. Clark, in his paper on growth-changes in some brittle-stars expresses the only formulation of the very important contribution of R. T. Jackson to the study of juvenile brittle-stars that I have seen. This law is a very real help in determining possible relationships between specimens otherwise obscure or impossible to differentiate. Briefly stated, we may say that, as applied to these forms, the base of an arm of a young form corresponds exceedingly suggestively with the tip of an arm of an adult specimen of the same species. However, the extent of localization varies greatly in different species, as I have found. One needs much study to determine accurately the position of a given specimen.

It is hardly possible, as I have pointed out, to formulate a general system of the group but among the groups examined the *Ophiolepidae* and the *Ophiocomidae* are noticeably separate and, containing few local genera of well marked characters can readily be separated both among themselves and from other families. Between the families *Ophiothricidae* and *Amphiuridae* I have found many points of contact as I did also between some *Ophiodermatidae* and the *Amphiuridae*. Beyond these generalizations I do not care to advance any opinion.

Following are my results upon those species examined. Extremes of measurement and a few notes on certain of the more obvious structural details are given. Other details can be made out from study of the plates.

Ophiocryptus maculosus Clark. The smallest specimen measured had its disc one mm. in diameter and with arms one and a half mm. long. Young of this species differ from adults in few skeletal details. The buccal fissures seem less marked and the arms relatively longer in proportion to the disc.

Ophioderma panamensis Lutkin. The smallest specimen measured two mm. across the disc and with arms eight mm. long. Juveniles of this species resemble adults in many points but they differ in others. The disc is set well apart from the arms. The characteristic notches between the arms in the adults are absent. The radial shields are scarcely marked. The branchial spines are set almost at right angles to the arms. Not figured.

Ophioplocus esmarki Lyman. The smallest specimen measured was one mm. across the disc and with arms eight mm. long. Juveniles of *O. esmarki* are always distinguishable by pinkish bands crossing the arms. This species is especially interesting on account of the schizogony that young specimens undergo.

Amphiodia barbarae Lyman. The disc of the smallest specimen measured was three mm. and the arms twenty-eight mm. long. These are always to be distinguished by the exceedingly long arms at least ten times the diameter of the disc. Young seem to bear many points in common with *O. panamensis*.

Ophioneris annulata Le Conte. Specimens of this species vary from about one half mm. to two mm. in diameter. They undergo schizogony in an unequal plane in certain cases. Like the adults the arms have three flattened arm-spines and with banded arms.

Ophiopteris papillosa Lyman. Measurements of the smallest specimen in this species found were for the disc three mm. and for the arms ten mm. These are distinguishable by the flat upper arm-plates and coarse arm-spines, but these are both characters that vary even in one specimen.

Ophiothrix spiculata Le Conte. I found but few specimens of this although the adults are abundant. The smallest specimen measured one mm. in diameter. The reduction in the comparative

size of the radial shields is especially noticeable in a series of specimens. One of the interesting features of this species is the great range of color variation found. This is true both in young and adults.

CONCLUSIONS:

1. A rational system in the brittle-stars is lacking. Such a system may result in part at least, from a complete study of growth-stages.

2. Jackson's law of localized stages repeating phylogenetic history seems to be well vindicated in this and other studies.

3. The groups examined seem to bear certain relationships to each other, as indicated above.

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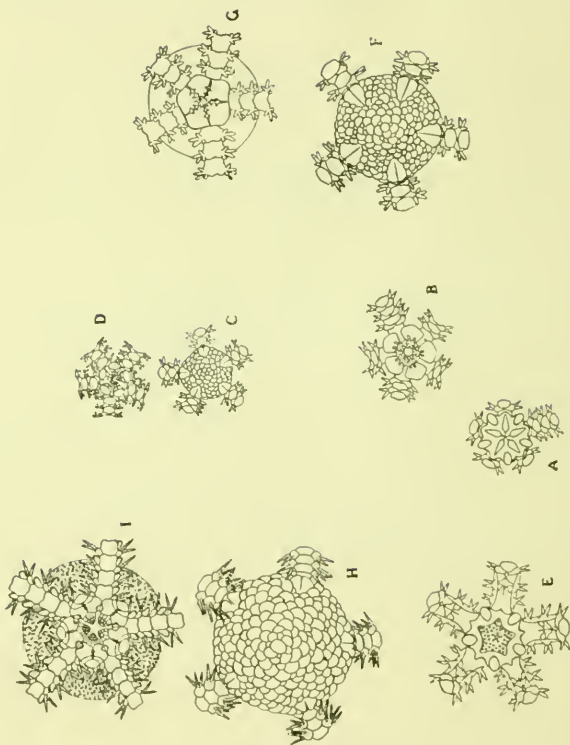
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EXPLANATION OF PLATES

All figures X10

Plate 1, *Ophiothrix spiculata*.

A, B; C, D; F, G; H, I, upper and lower surfaces of various sizes. E, Dorsal view of one whose ventral side is like A.

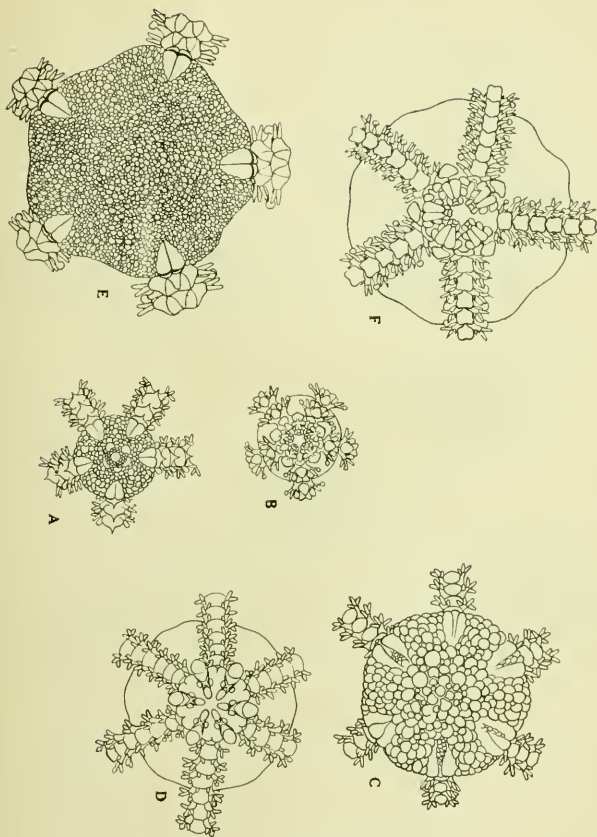


Plate III. A, B; E, F, *Amphipodia barbara*; C, D, *Amphipodia barbara*?

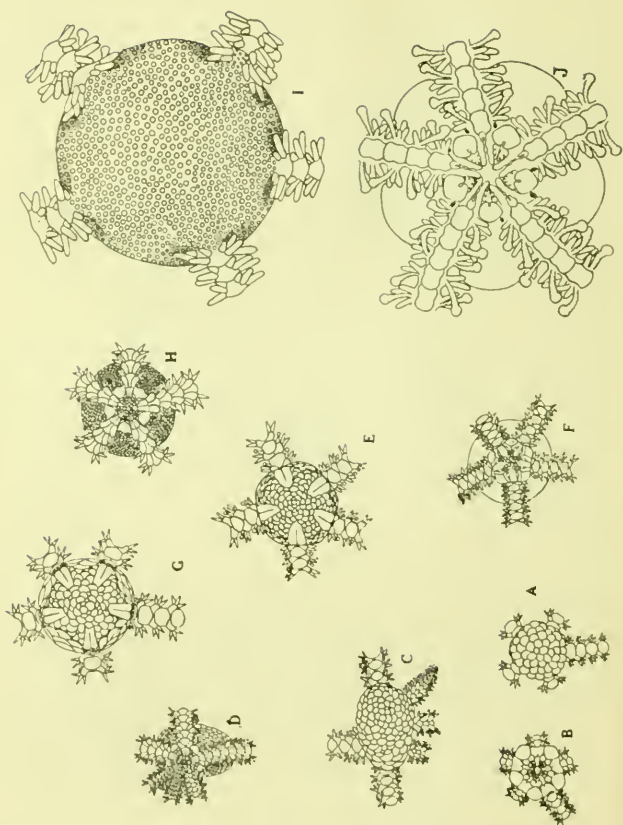


Plate II. A. and B, upper and lower surfaces of *Ophionermis annulata*.
 C and D, upper and lower surfaces of six armed *O. annulata*.
 E, F; G, H, upper and lower surfaces of *Ophioplocus esmarki*.
 I, J, upper and lower surfaces of *Ophiopteris papillosa*.

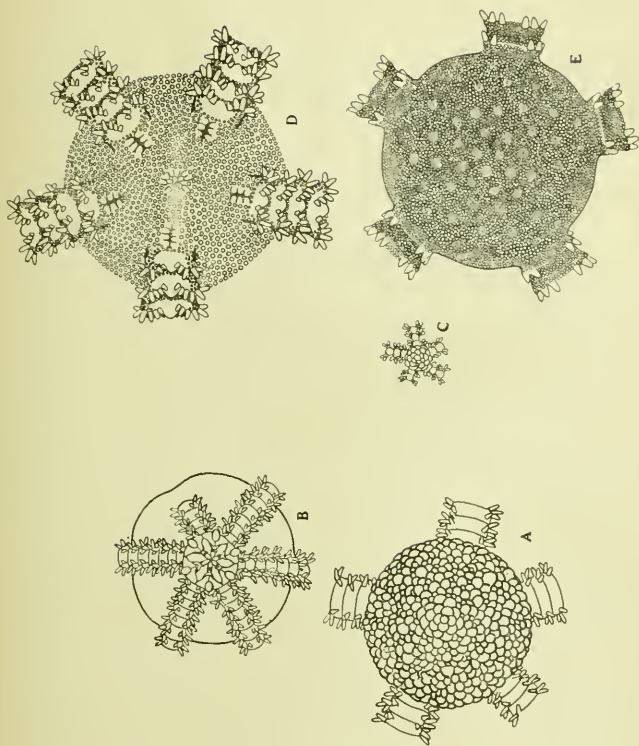


Plate IV. A, B, upper and lower surfaces of *O. annulatus*. C, Dorsal, E, D, dorsal and ventral views of *Ophicryptus maculosus*.

IX. The Bryozoa

ECTOPROCTA.

About the earliest observations on the nervous system of these animals was by Dumortier and Van Beneden in 1843. They described the central nervous system of fresh water forms as composed of two ganglia above the oesophagus joined by commissures. From the aboral part of the ganglion a pair of nerves runs to the oesophagus. They also considered that a pair of nerves supplied the epistome.

In 1848 Van Beneden speaks of but a single ganglion.

Allman, 1856, in fresh water forms describes a single unpaired oval ganglion. The two oesophageal nerves are represented as an oesophageal ring with enervation for the epistome.

Hyatt, 1865-1868, describes the central ganglion in *Plumatella* with the ganglion concentrated. The two long arms of the animal however, are capable of independent movement. The ganglion in *Trederecella* is spindle-shaped. In *Plumatella* the ganglion is kidney-shaped and as it doubles upon itself by movements of the animal it becomes heart-shaped. He describes a true nerve ring about the oesophagus. Nerves go to the middle and end intestine. Hyatt also describes nerves to the epistome and to the tentacles.

Nitche, 1869-76, has studied bryozoans quite extensively. He found a central cavity in the ganglion in embryonic stages. He recognized an oesophageal ring, intestinal nerves, tentacle nerves. He recognized on the tentacles bristles which he called taste bristles.

Claparede, 1871, in some bryozoans describes the nervous system of colonial forms; nerve strands running the length of the body were recognized.

Kraepelin, 1887, found the center of the ganglion in adult forms, and the shape of the ganglion of fresh water forms elipsoid. He also recognized peripheral ganglion cells in the ganglion. Oral nerves were seen, as well as nerves to the epistome.

Verworn, 1887, in a general way recognized ganglion cells.

Saefftiger, 1888, has especially added to our knowledge of the distribution of the nerves to the tentacle crown; he also considers a sympathetic system but says nothing of the sense cells in the tentacles although he describes the epithelium of parts of the animal.

Braem, 1890, describes the central ganglion of fresh water forms as hollow with an outer thinner oesophageal and a ventral thicker wall. He considers the inner part of the ganglion as largely fibrous.

Oka, 1891, has considered fresh water forms, especially *Pectinatella*. Like Saefftiger, he finds the ganglion with a cavity in the mature state. The ganglion is compared to a spindle bent in

the form of a U, with the concavity fitted to the anal side of the oesophagus in an oblique position with arms turned slightly upwards. The end of each makes a turn in the oral direction, and is continuous with a large nerve trunk which goes to the lophophore arm. The ganglion is in direct connection with the inner cell layer of the oesophagus, the outer layer of the latter enveloping it on all sides. The lophophore nerve trunks are likewise located between the outer and inner layers of the body-wall; they run beneath the outer layer of the lophophore covered below by epithelium. The ganglion contains a large cavity extending to the ends of the ganglion. The wall of the ventricle is very thin and epithelial in nature on all sides but the bottom on the anal side, where it is very thick as it joins the main part of the ganglion. This thick portion is distinctly separated from the epithelial part and is well seen in the fresh state as a somewhat reddish mass with a slight constriction in the median plane of the polype. It is this part that Hyatt took for the ganglion which he described as composed of two lateral masses connected by a thick commissure. The epithelial part is hard to recognize in surface views. A cross section of the lophophore trunks is kidney-shaped; in it the nerve cells are much crowded; the nerve cells are spindle-shaped, bipolar, with nuclei in the middle, closely packed together with few fibers between. The nerve trunks are thick and large as compared with the ganglia. The matter of a circum-oesophageal ring was not settled; this author did not find it. The colonial nervous system found in some marine Bryozoa for the purpose of controlling the movements of the members of the colony seem to be entirely lacking in the species *Pectinatella gelatinosa*, and this fact agrees with the behavior of the animals as they act independently.

Cori, 1893, does not give much further information about the nervous system of bryozoans.

Delage and Herouard, 1897, in a number of diagrams show the position of the ganglion in marine ectoprocts as being a single small ganglion ventral to the oesophagus. There are probably nerves going to the tentacles, to the body and to the alimentary canal, but these are not clearly shown in any case. A ganglion in the avicularium is shown by Delage and Herouard and they indicate by a series of diagrams how this ganglion might have been derived from a single zooid by a series of gradual transformations.

Ladewig, 1900, shows such a ganglion center in an avicularium of a marine ectoproct.

The sensory system of ectoprocts has been described by Nitsche on the tentacles of *Alcyonella* as stiff bristles to which he ascribes the sense of taste. Verworn, Kraepelin, Braem and others have seen these without ascribing special functions to them. It seems probable that the tentacles must have some special sense organs for touch or other senses.

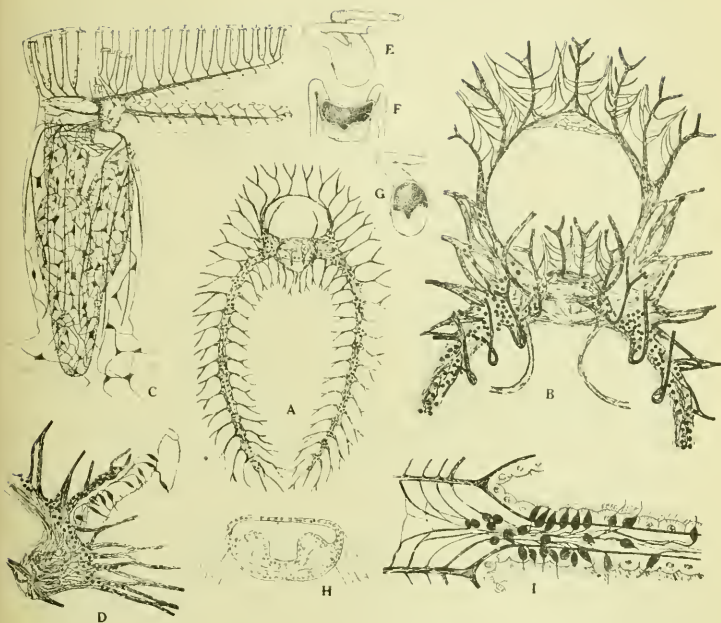


Fig. 19. NERVOUS SYSTEM OF FRESH WATER BRYOZOA. A. General view of the nervous system of *Cristatella*. B. Oral surface of upper end of central nervous system of *Cristatella*. C. General plan of the nervous system of *Cristatella*. The tentacles are all cut away in one arm and partly cut off in the other. The position of the alimentary canal is indicated. D. Side view of a portion of the chief ganglion showing the nerves of the epistome. E. Diagram of sense cells and nerve bands connected with a single tentacle. F. Diagram of a section from side to side of the central ganglion showing the cerebral cavity. A-D, I after Gerwerzhangen from *Cristatella*. E, F, G, and H. Surface longitudinal and cross sections through the ganglion of a fresh water bryozoan from Oka.

From the above review it will be evident that we know much more about the nervous system of fresh water forms than marine ectoprocts, and Gerwerzhagen, 1913, has still further extended our accurate knowledge of the nervous system of fresh water forms. Most of his information comes from the study of total preparations.

The general form of the nervous system is shown in Fig. 19A. The cerebral ganglion is connected with the two large ganglionic cords which have branches to the tentacles by way of the radial nerves, each of which has two branches. In the upper part of the figure is the oral nerve ring while below is the narrower epistomial nerve ring.

Fig. 19B. shows more detail in the region of the oral nerve ring and oesophageal plexus. It shows three bands of commissural fibers running across the cerebral ganglion.

Fig. 19C. shows the general outline of the whole animal with the tentacles partly cut away. Besides the general nerves there is the nerve plexus of the base which connects with that of other members of the colony.

Fig. 19D. is a side view of part of cerebral ganglion. The nerve supply to the epistome shows on the left.

Fig. 19E. shows the nerve supply to the base of a tentacle; two chief branches enter each tentacle, with sensory nerve cells.

Fig. 19F. shows a diagram of a cross section through the center of the cerebral ganglion.

In general then the nervous system of *Cristella* may be summarized as follows:

1. The ganglion is hollow with an extension into the two large ganglion cords.
2. There are two main branches running down each tentacle one from each adjoining radial nerve from the ganglionic cord. There are also strands from the bipolar sense cells in the epithelium of the tentacles. These afferent fibres join the radial nerves on each side.
3. There are two nerve rings, the epistomal or dorsal smaller one and the oral or ventral larger one, each with numerous secondary branches.
4. The sense cells in the tentacles, especially are bipolar. Multipolar cells are also found in the nervous system and nerve plexus.
5. There is a ganglion cell network in the wall which connects one member of the colony with another. This network joins

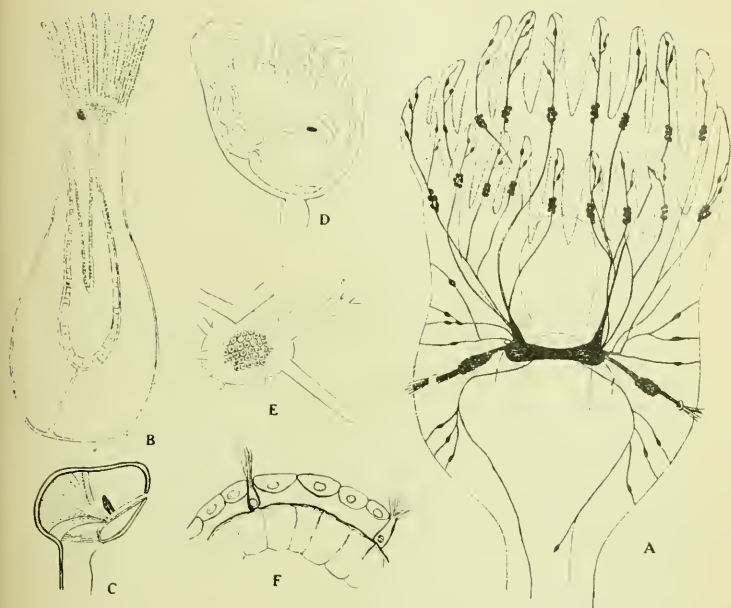


Fig. 20. BRYOZOA All but B and C from endoproctans. A. Diagram of the nervous system and sense cells of *Loxosoma*. Harmer. B. Longitudinal section of an estoproctan bryozoan from Delage and Herouard. The position of the ganglion is shown by a black area. C. An avicularian from *Bugula* showing ganglion after Ladewig. D. *Pedicellina* showing location of ganglion. E. Ganglion of *Pedicellina*. Nitsche. F. Diagram of sense cells in surface of tentacle of *Pedicellina*. Retzius.

with the similar multipolar network over the surface of the individual members of the colony. In the connecting portion of the colonial wall are no sensory cells so these nerve cells must have a motor function.

6. The sympathetic system is represented by fine nerves from the aboral surface of the ganglion to the dorsal and dorso-external wall of the oesophagus. Ventral fibers also join with the oral nerve ring by anastomoses.

There is a nerve network over the surface of the alimentary canal. At the beginning of the oesophagus and extending to the stomach there is a network of cells and fibers forming a sort of nerve ring. Further down all parts of the alimentary canal have a nerve plexus. The nerve net is especially abundant about the rectum. The function of the sympathetic system seems to be motor. The sympathetic system in the digestive canal consists of a nerve network of ganglion cells as well as stands of nerve fibers.

ENDOPROCTA.

Van Beneden, 1845, although he considers *Pedicellina*, gives little or nothing on the nervous system. Kowalewsky, 1867, discusses the development and Uljanin, 1869, gives the position of the ganglion in the same genus. Nitsche, 1875, shows the general position and chief branches of *Pedicellina*. Salensky, 1877, gives the general location of the ganglion in *Loxosoma*.

Harmer, 1885, gives one of the best early accounts of the nervous system of *Loxosoma*. He describes a dumb-bell-shaped ganglion, bipolar cells on the surface and a median fibrous part. Nerves pass from the ganglion to the tentacle prominences. There are many sense cells in the tentacles. Silver nitrate was used to determine the position of the sense cells. The ganglion is developed from the ectodermic floor of the vestibule and is connected with a well developed system of peripheral nerves ending in sense cells bearing tactile hairs on various parts of the body. The adult has no supraoesophageal ganglion. The nervous system of *Loxosoma* develops by ectodermic invaginations; the connection between the two parts is established secondarily.

Foettinger, 1887, represents the nervous system of *Pedicellina* by a brain more or less completely divided into two lateral lobes. It is formed by a mass of ganglion cells surrounding a fibrous center. From the ganglion several pairs of nerves pass.

Seeliger, 1890, gives the development and position of the nervous system in endoprocts.

Davenport, 1893, shows the position of the ganglion in *Unatella*.

Nickerson, 1901, in *L. davenporti* describes the brain as just in front of the intestine and above the stomach, between it and the

floor of the diaphragm. It is elongated transversely, the two rounded ends being composed of a surface layer of cells with deeper fibers. Some of the fibers form a commissure. From each end of the brain two bundles are given off; one on each side passes to the lophophore. Sensory bristles were seen from the tentacles. Dorsal sense organs as described in other forms are absent in this.

Stiasny, 1905, shows the ganglion of *Pedicellina* but with no detail. Retzius, 1905, shows the sensory nerves in the surface of *Pedicellina*. These sensory cells bear bristles and are connected with nerve strands which form a wide network of fibers. Sensory cells were found in the tentacles.

Assheton, 1912, found the nervous system in two species of *Loxosoma*. The branches are figured and sense cells are mentioned on the hypostome, lophophore and tentacles.

I have been able to study the reactions of two Pacific coast species of endoproctans. In *Barentsia gracilis* Hincks, the conditions are much as in *Pedicellina*. The ganglion is small and in the usual position. The animals are colonial with narrow strands connecting the individual members of the colony; the muscular bases of each individual cause them to rotate in an active manner. General conditions in *Myosoma spinosa* Robertson are similar except that the whole stem is flexible. In *Barentsia* the polype at the end of the stem is movable at its stalk. The ganglion is much as Nitsche describes. There is some indication of sense cells as shown by Harmer as demonstrated by the methylene blue method although I never obtained a perfect picture. The tip of the stem is slightly smaller where it joins the body of the individual and methylene blue shows bipolar cells at this point. Along the stem there are sensory pits which are the only breaks in the strong chitin-like covering of the ten elongated cells of the stem. In *Myosoma*, in place of the pits on the skin there are well developed hollow hairs much like those of arthropods.

Tactile or other stimuli may cause a rotation of the stems without a contraction of the tentacles, but severe stimuli will also cause the tentacles to contract. Stems with their tips cut from the body continue to rotate when stimulated. Movements of the body of the polype on the stems may be caused by tactile stimuli. The effects of stimulation may be carried from one polype to another through the connecting stems. One polype in line with others may be fatigued so that it will not carry the stimuli to others.

The stems and bases of both species seem capable of exciting movements of the individual as a whole better than the tentacles or body. In the rotating movements the tentacles are not often retracted unless the stimulus is very severe or the tentacles themselves are touched.

The control of movements of the tentacles and body are probably centered in the ganglion. The excitation to the rotation of

the stems is effective through the stems themselves and the presence of the ganglion is not necessary for these characteristic movements. The conduction from one member of the colony to another seems more evident than from the base or stem to the tentacle region, and vice versa.

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The Skull of *Notothalamus Torosus*

Sarah Marimon

There are twenty-eight bones in the entire skull of *Notothalamus torosus*. There are, however, only fifteen different kinds, since thirteen are paired.

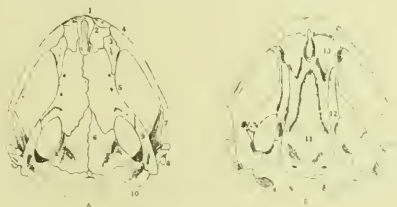
These paired bones are: nasals, ectethnoids, maxillaries, frontals, parietals, squamosals, quadrates, ptergoids, occipitals, squamopalatines, sphenethnoids, and (of the mandible) dentaries and articulares.

The unpaired bones are: the parasphenoid and the premaxillary.

The premaxillary (1) is the bone which forms the external division between the two nares. It consists of a rather thin dividing bone, which broadens out to form a broad flat base. Dorsally the dividing bone diverges posteriorly to form two slender processes which join at the ends with the premaxillary processes of the frontal bones, and articulate on the exterior sides with the two nasal bones. Ventrally the dividing bone broadens out suddenly into a broad flat base which forms the most forward portion of the roof of the mouth, and serves as a connection between the two maxillaries.

The nasals (2) are two irregularly shaped bones, each of which articulates on the interior side with a premaxillary process, on the exterior side of the ectethnoid and the maxillary. Anteriorly the nasals bound the dorsal side of the nasal cavity.

The ectethnoids (3) are two triangular bones located on either



FIGURES

In lettering these figures I have used the following method:

Each bone on the skull is marked with a large number. Throughout the figures, each bone goes by its number. When an articulation with a certain bone is indicated a small figure is used. The bone itself bears a large figure. When the bone borders on a cavity, or has a free edge, that portion of the bone is not numbered.

Upper or outer surfaces are indicated by numbers, under or inner surfaces are indicated by the same numbers prime (1').

side of the anterior portion of the skull. Each is so placed that one half of its surface articulates with the dorsal surface of the skull, while the other half forms a portion of the side of the skull. Through the center of the ectethnoid there is a dividing ridge which separates its dorsal surface from its lateral surface. The dorsal surface articulates anteriorly with the maxillary and the nasal, and posteriorly with the frontal. The lateral surface articulates anteriorly with the maxillary and posteriorly with the frontal; a small portion remains between these two articulations and this portion bounds part of the opening into the olfactory fossa.

The maxillaries (4) are long slender bones, which, together with the premaxillaries bear the teeth of the upper jaw. The maxillary articulates only anteriorly and diverges posteriorly to form a long rather slender process extending about one-half the length of the skull. Before the maxillary articulates with the main body of the skull it diverges on the inner side into two portions; the upper portion articulates with the dorsal bones of the skull, while the lower portion articulates with the ventral bones. The

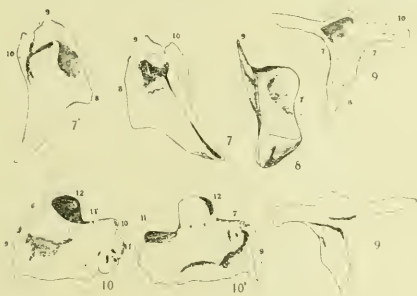


hollow depression resulting from these two divergences forms the opening into the olfactory fossa. Dorsally the maxillary articulates with the nasal and the ectethnoid; and ventrally with the premaxillary and the squamo-palatine.

The frontals (5) form a little less than one-half of the dorsal surface of the skull. They lie in contact with one another for about two-thirds of their length, diverging anteriorly to form a pair of short premaxillary processes, and diverging posteriorly to form two processes,—a blunt rather broad parietal process and a long slender process which articulates with the squamosal bone. On the ventral surface of each frontal is an out curving ridge which serves for the attachment with the sphenethnoid.

The parietals (6) lie in contact with one another for their entire length. They are smaller than the frontals, however, they form less of the dorsal surface of the skull than their real size would warrant, since at their articulations with the frontals these bones extend down over them. Posteriorly each parietal articulates with the occipital, and postero-laterally with the occipital and the sphenethnoid.

The occipitals (10) are the most posteriorly placed bones in the skull. The dorsal surface of each is more or less regular, diverging toward the median line to form a short rather slender process which articulates with the other occipital. Anteriorly the occipital connects with the parietal while posteriorly on the external side, it articulates with the squamosal. The ventral surface of the occipital is very irregular and the articulations with other bones are not continuous. Posteriorly on the external side it diverges to form a short process, which unites with the squamosal and forms the posterior corner of the skull. On the inner aspect of the ventral surface, adjacent to the squamosal articulation, is a projecting knob-like process with which the ptergoid articulates.



The most posterior portion of the occipital toward the median line, diverges to form a knob-like condyle which articulates with the first vertebra. Anteriorly the occipital articulates with the parasphenoid and antero-laterally diverges to form a projection which articulates with the sphenethnoid.

The squamosal (9) is a peculiar T-shaped bone, standing in an almost vertical position in the skull. The bar of the T, forms a part of the dorsal surface of the skull and articulates at the anterior end with the frontal bone; at the posterior end with and up past the point where the stem of the T diverges, it articulates with the occipital bone. The stem of the T projects ventrally almost at a right angle, and articulates with the ptergoid and the quadrate.

A true squamosal bone is sometimes considered not to exist among Amphibia, and the so-called squamosal bone is considered to be rather an investing bone on the surface of the quadrate, and for this reason is sometimes called the paraquadrate.

The quadrate (8) is an irregularly shaped little bone with somewhat the appearance when in position, of a wedge between the ptergoid and the squamosal. Functionally it serves as a piece interposed between the skull and the mandible, and forming an articular surface for the latter. The knob-like anterior ventral end of the quadrate consists of an articular process, fitted with a socket to receive the rounded knob (articulare) of the mandible.

The ptergoid (7) is a spade-shaped bone which projects downward from the ventral side of the skull. It articulates with the main body of the skull by means of a hollow, rounded process which articulates down over a knob-like projection on the occipital bone. Aside from the articulation with the occipital, the ptergoid articulates posteriorly with the quadrate and the squamosal.

The squamo-palatines (13) are long rather slender bones, flattened anteriorly. At about one-third of their length, from the



anterior end, they articulate dorsally with the parasphenoid and project down onto that bone for the remainder of their length. These projections are provided with teeth along the median line. Anteriorly the squamo-palatines articulate with the premaxillary and the maxillaries.

The parasphenoid (11) is the flattest and most extensive bone in the skull, and forms nearly the whole floor of the brain case, and at the same time the roof of the mouth. It is nearly the shape of a parallelogram with rounded corners, but it is a little broader in the optic region and becomes somewhat narrowed anteriorly. It

has no especial markings or features other than the impressions made by the bones which come in contact with it. On its ventral surface are two long narrow impressions left by the squamopalatines.

The sphenethnoids (12) are the bones which serve as walls to hold apart the dorsal and ventral surfaces of the skull. They are rather long bones, about three-fourths as long as the parasphenoid. They articulate posteriorly with the occipitals, their dorsal edge articulates with the frontals and parietals, their ventral edge with the parasphenoid. Anteriorly they bound a portion of the openings into the occipital fossae.

The mandibles of *Notothalamus torosus* are each composed of two bones, the dentary and the articulare.

The dentary (14) is that part of the mandible which bears the teeth. It is a long slender, curved bone, articulating anteriorly with the other dentary, and widening out posteriorly to articulate with the articulare.

The articulare (15) is that part of the mandible which diverges posteriorly to form a rounded knob which fits into the articular socket of the quadrate. Anteriorly, on the median side it fits down into the dentary bone.

A New Aphis on California Sage

APHIS HILTONI n. sp.

(Figure 1)

By E. O. Essig, Division of Entomology
University of California

Apterous Viviparous Female.—

(Figure 1, A). Length 1.3 mm., width of abdomen 0.9 mm. Prevailing color pale green, the dorsum partially covered with a fine white powdery wax which is arranged in minute pore-like or mosaic rings. The areas not so covered appear dark in the illustration. There are numerous black pigmentations dorsally and laterally on the epidermis of the mounted specimens. The cornicles, cauda and anal plate; all of the legs excepting the basal three-fourths of the tibiae; and antennal articles, VI, V, II, I and the tip of IV are black or dusky. The remainder of the antennae and tibiae are yellow. The rostrum extends slightly beyond the base of the abdomen. The antennae are shorter than the body, the relative lengths of the articles being:

I. 0.065 mm., II. 0.055 mm., III. 0.227 mm., IV. 0.167 mm., V. 0.155 mm., VI. 0.280 mm., (base 0.130 mm., spur 0.150 mm.), total length 0.949 mm. There are the usual sensoria on articles V. and VI. The prothoracic tubercle is well pronounced. There is also a well defined pair of anterior and a pair of posterior abdominal tubercles (Figure 1, A. tub. i, ii, iii). The tarsi are small and one-third as long as the cornicles. (Figure 1, At.). The cornicles are black, cylindrical and somewhat tapered towards the tip, straight, slightly imbricated; 0.37 mm. long, and 0.06 mm. wide at the base. The cauda and anal plate are black (Figure 1, A. cauda).

Winged Viviparous Female.—

Length 1.20 mm., width of abdomen 0.56 mm. Prevailing color black with abdomen and legs dusky yellow. The dorsum may also be partially covered with a fine white powdery wax. The antennae (Figure 1, W. ant) are dusky to black throughout, the length of the different articles: I. 0.070 mm., II. 0.050 mm., III. 0.200 mm., IV. 0.155 mm., V. 0.153 mm., VI. 0.280 mm. (base 0.125 mm., spur 0.155 mm.), total length 0.908 mm. Article III usually has four or five large circular sensoria along the lower side, but there are sometimes six. The usual sensoria occur on V and VI. The rostrum reaches to the second abdominal segment. The prothoracic and abdominal tubercles are much like those in the apterous form and are illustrated in Figure 1, W. tub. The wings (Figure 1, W.) are normal in venation as illustrated. The lengths are:

primary 2 mm., secondary 1.2 mm. The cornicles are black, imbricated, cylindrical, somewhat larger near the base, the outer margin straight, the inner margin as illustrated (Figure 1, W. corn.). The length 0.10 mm., greatest width 0.05 mm. The cauda and anal plate are black and as illustrated (Figure 1, W. cauda).

RELATIONSHIP—This species has been carefully checked with *Aphis reticulata* Wilson, *A. oregonensis* Wilson, *A. hermistonii* Wilson, *A. tridentata* Wilson, *A. frigidae* Oestlund, and *Aphis artemiscola* Williams occurring in Oregon on *Artemisia tridentata*, and does not agree with any of them or other closely related species.

HOST—The species occurs in dense colonies on the apical twigs of old man or California sage, *Artemisia californica* Less.

LOCALITY—In Laguna Canyon one-half mile above Laguna Beach, California.

DATE OF COLLECTION—July 13, 1921.

COTYPES—The above description was made from a series of cotypes consisting of ten slides and over one hundred mounted individuals. The cotypes are in the author's collection.

The species is named after Dr. Wm. A. Hilton, Professor of Zoology, Pomona College, under whose supervision, inspiration and energy a most wonderful type of biological instruction is being given each summer at the Laguna Beach Laboratory.

Figure 1.—*Aphis hiltoui* n. sp.

A. Apterous viviparous female; A. tub., body tubercles of apterous female; i, prothoracic; ii, front abdominal; iii, posterior abdominal; A. corn., apterous cornicle; A. cauda, apterous cauda and anal plate; At. t., apterous tarsus; A. ant., apterous antenna; W, wings; W. ant., antenna of winged female; W. corn., cornicle of winged female; W. cauda, cauda and anal plate of winged female; W. tub., body tubercles of winged female; i, prothoracic; ii, front abdominal; iii, posterior abdominal.

X. Phoronida and Actinotrochia

Wright in 1856 described the first species of *Phoronis*. Dyster, 1858, suggests two oesophageal ganglia. He found that the creatures were not particularly sensitive to light. I have a reference to a paper by Kowalevsky, 1861, on the anatomy and development of *Phoronis*, but as I have not seen it or a review of it I do not know how much the nervous system is considered.

Caldwell's publication of 1883 is the next paper of importance. He describes the nerve processes in connection with the ectoderm; both fibers and ganglion cells occur in the ectoderm. There are concentrations of the nervous tissue about the mouth to form a post-oral nerve ring; the anus is outside of this. The ring forms a line along the base of the tentacles formed like a horse shoe. In front of the ring is a pair of sense organs, the ciliated pits in the concavity of the lophophore on either side of the anus. There is an epithelium here with sense cells, ganglion cells and nerve fibers. The nervous system is further continued on the left side from the dorsal part as a cord or strand just outside the basement membrane.

McIntosh, 1888, in *P. buskii* describes a similar epidermal system concentrated about the mouth to form a post-oral nerve ring with the anus outside. The ring follows the line along the base of the tentacles and to the "ciliated pits" or concavity of the lophophore on either side of the anus. The nervous system has sense cells and ganglion cells and nerve fibers. On the left side is a cord through the body. The left longitudinal nerve tube or tubes of Caldwell is not described.

Andrews, 1890, in a new species describes the "glandular pit" of the lophophore and a large "nerve rod" on the left side, solid and surrounded by epidermal cells. It seems to have a fibrillated or possibly only a coagulated structure. The rod extends through a considerable distance and ends in a peculiar ring of epidermal nerve substance about the mouth. At this region there are two symmetrically placed nerve rods but the right is short.

Benham, 1889, finds the nervous system immediately below the epidermis as Caldwell was first to observe. Passing aborally from the lophophore ridge the basement membrane is seen to separate from the epidermis by a narrow ground substance not readily stained. In this granular substance are a few rounded nuclei belonging to small nerve cells. Fibers are also found coming from the epithelial cells of the surface. This nerve band follows the ridge of the lophophore passing around on the oral side and curves at the side of the nephridial ridges following the spiral course of the lophophore. It always keeps along the outer edge of the tentacles. From this band nerve tissue goes to each tentacle passing along its inner surface. A nerve goes to each nephridium and a nerve layer to the epistome, this being the only dorsal part of the nervous

system. There are no concentrations any place to form a ganglion; the chief nervous system lies ventrally. Two longitudinal nerve tubes or nerve bands are described running the length of the body. The nerve strands may give the appearance of tubes due to shrinkage; epithelial cells seem to compose it and the tissue does not look like nervous tissue. These longitudinal tubes or nerves may be some sort of sense organ.

Cori, 1890, adds nothing to the general knowledge of the nervous system.

Torrey, 1911, in *P. pacifica* gives a partial description of the nervous system as like that of *P. architecta* with the exception that "The two longitudinal cords which are of exceedingly unequal length, instead of continuing in the nerve ring of the lophophore, are continuous across the median line at the level of the median mass of ganglion cells. The loop thus formed is closely applied to the latter and touches the lophophore nerve on each side of the rectum, apparently without fusing at either point." I have found no such condition in several good series of well stained *Phoronis pacifica*. Either this was an individual difference or Torrey's material was poorly fixed.

Schultz, 1903, discusses the regeneration of the central nervous system.

De Selys-Longchamps, 1907, described the circular nerve ring and ganglion and the lateral nerve of Caldwell on the left.

Pixell, 1912, discusses two new species of Phoronida.

In *Phoronis rancouverensis*, there is the usual ring of nervous tissue at the base of the lophophore; from it five nerves continue up the tentacles. Across the dorsal surface in front of the anus is a large ganglionic mass composed of fibers and cells with large nuclei. This tissue is everywhere in intimate relation with the inner ends of the epithelial cells. In some sections two small lateral nerve cords ran along the right and left sides of the body close to the point of attachment of the lateral mesenteries and projected into the basement membrane. He describes these as, "punctated tissue." They are very short. Nervous tissue was found in the center of the pit at the proximal end of the body and also along the alimentary canal on the outer side of the epithelium especially marked in the region of the oesophagus opposite the nerve ring. Gilchrist, so he says, suggests this patch as an organ of taste.

Phoronopsis hamesi has a similar condition of the nerve ring but the ring is narrower and more elongated than in *Phoronis*. A conspicuous nerve cord extends down the left side. In the nephridial region it is separated from the epithelium and embedded in the basement membrane; after passing internally to the nephridial duct it turns outwards and rejoins the epithelium a little to the oral side of the lateral mesentery. From here it extends as a con-

spicuous cord in contact with the epithelium and projecting slightly into the basement membrane. The center is of a clear substance and about this center are nerve cells.

Harmer, 1917, in *Phoronis ovalis* gives the position of the nerve ring which he shows thickened on the dorsal side.

I have had some opportunity to study *P. pacifica* and a species of *Phoronopsis*. It is quite important in studying the serial sections of this group that rather perfect preparations be available, a condition not altogether easy, as sand often interferes with good sections. However a number of perfect preparations were obtained.

In general I found the nervous system much as already indicated by the many of the others. In *P. pacifica* I found central nervous system to have its chief concentration a little below the

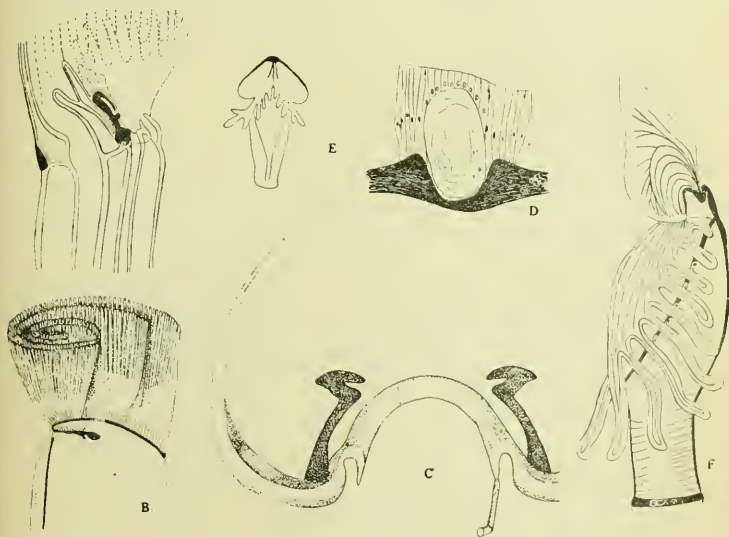


Fig. 21. A. Section showing position of nervous system of *Phoronis* after Schneider. B. Nervous system in *Phoronis* after Schneider. C. Diagram of a reconstruction of the nervous system of *Phoronis* showing longitudinal nerve cord on the right. Not all of the nervous system going to the tentacles is shown at the left. D. Section of nerve cord with epithelial cells on the outer surface and basement membrane in dark below. E. Actinotrocha larva showing the nervous system after Inedia. F. Diplochorda, after Masterman.

level of the anal opening and the nephridial tubules. This thickest portion of the nervous system directly continues with the epithelium of the surface of the body and is dorsal to the anal papilla in the depression caused by the anal prominence; from here the thickening passes toward the tentacles sending fibers to the lophophore and the tentacles. The lophophore depression on each side marks off the chief thickening of the nervous system. This central part, although continuous with the epithelium is made up of a distinct mass of fibers and cells. At this point three chief centers of cells are found among the fibers while out laterally strands run to the lophophore depressions and out to the tentacles. There is quite a mass of fibers and cells in the region of the lophophoral depression. Running out ventrally on the left side just medial to the lophophoral depression and between it and the left nephridium is the clear cord of unknown function noticed first by Caldwell. This cord surrounded partly by cells comes to run farther ventrally until it passes through the basement membrane of the body-wall and comes to lie just under the epithelium. This end does not seem to be of nervous tissue, although it is connected with the central part of the nervous system.

If I understand Torrey's description aright his material must have been too poorly fixed to show the relationship of the nervous system for in well preserved specimens the cerebral nervous system is continuous laterally with the lophophoral organs as well as with any lateral or longitudinal extensions of the nervous system. My observations both on *Phoronis* and *Phoronopsis* agree closely with those of Pixell. In *Phoronopsis* the central nervous system seems more elongated, as Pixell found.

With the exception of the central part of the nervous system the nerve cells are not clearly different from the epithelial cells, but careful study shows at the bases of the cells as well as farther down, nerve cells with their fibers directed into the basal mass of fibers. In the epithelium are bipolar cells, some of which may be sensory, although many of the prominent strands are those of supportive cells.

ACTINOTROCHA.

It seems best to consider the larval stage of *Phoronis* briefly at this place. Schneider, 1862, in his discussion of the development of *Actinotrocha* does not consider the nervous system. Caldwell has the first work of importance but his account, according to MacBride, implies that the apical plate and adjacent ganglion of the larva are lost, and the cerebral ganglion of the adult must be a new structure. But in every trochophore so far studied the apical plate with its ganglion forms the material which persists to the adult condition.

Masterman's paper of 1898 is a very important one. He mentions Wagner, '47, as the first to describe the nervous system. Masterman describes a central ventricular ganglion in the mid-dorsal line at the base of the prae-oral lobe, composed of ganglion cells and fibers. The ganglion is a proliferation of the inner cells of the epiblast. Nerve tracts radiate in almost every direction.

The nervous system may be summarized as follows:

1. Central ganglion in front collar region and between this and the prae-oral lobe. The epiblast in front is depressed to form a neuropore.

2. A ring about the posterior part of the collar is continued dorsally and ventrally giving off fine double groups of nerve tracts to the anal end of the body.

3. Groups of fine nerve tracts continued dorsally along the trunk from the anterior end of the collar.

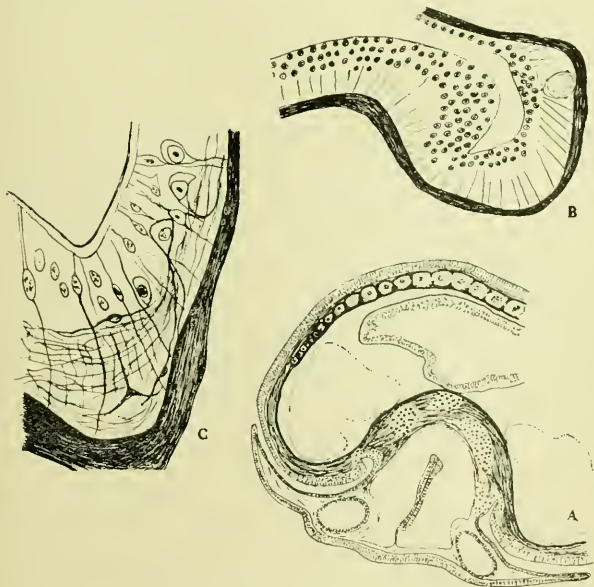


Fig. 22. A. Section through body and central nervous system of *Phoronis*. B. Small portion of lopophore showing depression. C. Small portion of the nervous system of *Phoronis* enlarged to show nerve cells.

4. A ring about the anal end of the trunk into which dorsal and ventral tracts lead.

5. A ring about edge of prae-oral lobe, joined at each side to the ganglion and in median front region by three main tracts running in mid-dorsal line.

6. A diffuse plexus of fibers at the base of all the epiblastic layer, including fibers of ventral collar region, which pass forward and dorsally to meet the ganglion.

Ineda, 1901, found no collar, nerve ring or dorsal or ventral commissure in the larva. He also failed to make out presence of the peri-anal ring. If present it is represented by a small number of parallel fibers. The main nerves were three in number close to each other and parallel along the mid-dorsal line of the trunk but confined to only a few sections posterior to the first pair of tentacles. There was found however a very complex and beautiful system of nerve fibers seen on the prae-oral lobe. Fibers are very numerous and fine and radiate from the ganglion on all sides towards the free margin of the prae-oral lobe. In the median line and anterior to the ganglion fibers are three long parallel strands on which the apical sensory spot is situated, not far from the ganglion. After passing through the sensory spot strands fray out into fine fibers which continue to the free margin of the prae-oral lobe. Fibers from the ganglion do not show a regular radial arrangement, but arise from the lateral edge of the ganglion and soon take an anterior direction. Sometimes near the ganglion there is an anastomosis of fibers, but probably more apparent than real. There are nerve endings in the prae-oral ciliated belt. There is probably an incomplete development of nerve elements in the collar and trunk region. He finds no neuropore and believes that Masterman's structure is due to contraction.

De Selys-Longchamps, 1902, gives a rather complete description of the nervous system. The central ganglion is a dorsal expansion of the epidermis with fibrillar substance below the surface. The depression which Masterman calls neuropore is not such a structure. There are three cords of the nervous system, the median is most developed. The apical organs are organs of sense.

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The Occurrence of *Polygordius* Adult at Laguna Beach

William A. Hilton

For a number of years now we have taken *Branchiostoma* just off shore in rather coarse sand, but it was not until the summer of 1920 that we began to look for archiannelids. A few doubtful specimens were obtained from sea weeds but nothing that we could be sure were the animals sought. We never thought to search the sand in which *Branchiostoma* was taken until after reading in the monograph on *Polygordius* how the creatures were obtained near Naples. With the hint that these animals were sometimes associated we examined with great care some hundreds of pounds of coarse sand in which some few *Branchiostoma* had been found and from this two specimens were obtained, one dead and one living. These were without question of the genus *Polygordius* although to make the matter more certain sections were made. Although the genus is certain, the species remains undetermined because the caudal ends of the animals were not perfect.

The living specimen was *very* active. At first it was taken to be a rather long round worm but the characteristic antennae at the head region caused it to receive more attention.

So far as I can tell, this is the first record of the *adult* of *Poylgordius* being found in North America in its natural environment at least, for some have been reared from the larval forms at Woods Hole.

(Contribution from the Zoological Laboratory of Pomona College.)

Insect Notes from Laguna Beach, California

By E. O. Essig, Division of Entomology
University of California

The following notes were made during the Summer Session at the Pomona College Marine Laboratory, Laguna Beach and vicinity during June and July, 1921.

ORTHOPTERA¹

Two earwigs, *Anisolabis annulipes* Lucas and *A. maritima* Brun., were commonly taken in the canyons in damp places under stones, logs and in wet leaves. The former occurred under stones close to the creeks.

The cockroach, *Arenivaga (Homologamia) erratica* (Rehn), was taken under a large stone. The specimen taken was apparently full grown and a wingless male. A winged female was also collected.

The mantids, *Stagmomantis californica* R & H and *Litaneutria obscura* Scudd., were both taken on the hills near the ocean beach during July 1921.

The common tree cricket in the Laguna Beach region proves to be *Oecanthus nigricornis* var. *argentinus* Sauss. A number of these were taken during July.

The red Jerusalem cricket, *Stenopelmatus fuscus* Hald., was taken in a rotten log in Niguel Canyon. The common species at Laguna Beach which regularly traverses the streets at night and may often be found in the morning, is *S. longispina* Brunner (Syn. *S. irregularis* Scudd.).

The large blue-winged grasshopper, *Leprus glaucipennis* Scudd., proved to be a match for the most active entomologists and eluded many a net. The species measures from 2 to 2½ inches long and the color matches perfectly the color of the soil on the hills, back from the ocean where it occurs. The blue under-wings easily characterizes it.

THYSANOPTERA

Western grass thrips, *Frankliniella (Euthrips) occidentalis* (Pergande)². A pale yellowish-brown species was abundant in the heads of *Juncus xiphiodes* Meyer growing in fresh water at the mouths of the canyons near the ocean.

¹ Determined by A. N. Caudell, Bureau of Entomology, U. S. Dept. of Agriculture.

² Determined by A. C. Morgan, Bureau of Entomology, U. S. Dept. Agriculture.

The Christmas berry thrips, *Trichothrips ilex* Moulton, occurs in all stages upon the tree malva, *Malvastrum fasciculatum* (Nutt.). The young are bright cardinal red with the head, antennae, dorsum of prothorax, legs, and last abdominal segment black. The adults are entirely black. The insects feed on the stems and undersides of the leaves and the brilliant red nymphs are often present in considerable numbers.

This species also attacks the Christmas berry, *Heteromyles arbutifolia* (Lindl.) and a variety *Trichothrips ilex dumosa* Moulton occurs in southern and central California on scrub oak, *Quercus dumosa* Nutt.

HEMIPTERA

The Crackling cicada, *Cacama crepitans* (Van Duzee).- One of the most interesting insects in the hill region is the crackling cicada, so-called from the various crackling sounds intermingled in the long sonorous buzzing or droning which is at times so deafening. When captured they make a terrific high-pitched noise. The adults may be observed resting near the tops of various shrubs, but appear to prefer the California sage, *Artemisia californica* Less.

The black scale, *Saissetia oleae* (Bern.), is abundant at Laguna Beach, having been dispersed far over the hills infesting many native plants including the California sage, *Artemisia californica* Less., willows (*Salix* spp.), and the lemonade or sour berry, *Rhus integrifolia* B. & H.

The Cabbage Bug, - *Murgantia histrionica* Hahn.- The native black phase of this species, described as *M. nigricans* by Cockerell, occurs in great numbers upon the wild mustard, *Brassica campestris* Linn., and more particularly upon the wild bladder-pod, *Isomeris arborea* Nutt., growing on the sea coast hills and in the valleys of Southern California. On the latter plant it overwinters and survives the dry years when the mustard fails to appear. The writer believes that the above form of the cabbage bug has long been a resident of Southern California where for ages it has subsisted upon the two plants listed and should be considered as a native insect.

The eggs are often heavily parasitized by a minute black encyrtid, *Ooencyrtus johnsoni* (Howard). Adults of this parasite were reared from eggs taken chiefly from the wild bladder-pod growing on the hills near the ocean from Balboa Beach to San Juan Capistrano. They issued in greatest numbers during the month of July.

¹ Determined by A. B. Gahan, Bureau of Entomology, U. S. Dept. of Agriculture.

DIPTERA⁴

The common kelp fly, *Fucellia rufitibia* Stem, was particularly abundant on decaying kelp along the beach during the summer. In some instances the flies completely cover the masses of seaweed and rise in clouds when disturbed. It would be interesting to know the larval habits of this species.

The lemur syrphid, *Baccha lemur* O. S., was reared in considerable numbers from *Erium lichtensioides* Ckll. on California sage, *Artemisia californica* Less., which was abundant in the Laguna Beach Canyon.

The small gray leucopis, *Leucopis griseola* Fall., was reared in immense numbers from the leaves of muskmelon vines which were severely infested with the melon aphid, *Aphis gossypii* Glover. The small larvae and pupae were abundant on the undersides of the leaves. That a large proportion of the muskmelon vines growing along the ocean between Laguna Beach and San Juan Capistrano, were not entirely destroyed, may be credited to the efficacious work of the larvae of this fly. I have never seen a predaceous maggot so numerous.

LEPIDOPTERA

The Sycamore borer, *Synanthedon* (*Aegeria*) *mellinipennis* (Bdv.).⁵ The work of the larvae of this moth on the trunks of the Western Sycamore or plane tree, *Platanus racemosa* Nutt., is very characteristic, consisting of numerous tunnels in the inner bark and the expulsion of quantities of reddish-brown frass which collects in the crevices of the bark and around the bases of the trees, at once calling attention to the presence of the insect.

The infestations occurred on large trees and was confined to the trunks from the ground to a distance of about six feet. Many of the trees were infested with great numbers of caterpillars, but no evidence of serious injury to the general health of any of the infested trees was noticeable. The moths mimic in color, size and flight the common yellow jacket, *Vespa germanica* Linn. Indeed so great was the resemblance that the moths hovering about the tree trunks were first thought to be yellow jackets until they alighted.

A single grove of western sycamore, comprising some fifty trees, in Niguel Canyon was the only one observed to be infested by this moth, although there were numerous other trees in the different canyons around Laguna Beach.

The western sycamore is apparently the native host of this species, which is recorded from California and Colorado, without previous host records.

⁴ Determined by J. M. Aldrich, U. S. National Museum.

⁵ Determined by August Busck, U. S. National Museum.

HYMENOPTERA

The Yellow and Black Mud-dauber, *Sceliphron servillii* Lepeletier.-This interesting dauber is common along all of the streams in the vicinity of Laguna Beach. The elongated mud cells about one inch long are built singly or placed side by side in series of from two to four and the whole covered with a continuous layer of mud completely obliterating the outlines of the individual cells. The cells were commonly placed on the undersides of large rocks or boulders in the near vicinity of the fresh water streams and often at the mouths of the canyons near the ocean. The nests were stored chiefly with yellow and brownish-gray crab spiders.

In the cells and attacking the larvae of the mud-daubers was often found the maggot of a tachina fly, which proved to be *Pachyaphtalmus floridensis* Townsend. The adults of this most interesting fly escaped from the masonry cells by the expansion and retraction of an inflatable bladder-like organ in the front of the head (ptilinum?) which was used to moisten the mud and then scrape it away. Adults confined in glass vials were easily observed to continually endeavor to work their way through in this manner. Not all of the flies appeared to possess or to use such an organ, but whether or not this is a sexual characteristic was not determined.

The fire ant, *Solenopsis geminata* Fab., was perhaps the commonest ant in the vicinity of the laboratory. During July the ants were swarming from their ground nests in great numbers. The workers are small, entirely reddish or with small rounded black abdomens, the winged females are reddish throughout while the winged males are black.

* Determined by J. M. Aldrich.

XI. Brachiopoda

Perhaps in no group of animals is our knowledge of the general arrangement of the nervous system in such an unsatisfactory condition. Various published accounts are not altogether in accord even when the same species is studied.

Owen, 1835, seems to be the first to detect the nervous system. He describes white filaments which traverse the visceral cavity and end in muscles.

Huxley, 1854, considers the nervous system to be a ring of nervous tissue about the oral opening.

Gratiolet, 1857, 1860, describes a considerable mass of ganglionic material encircling the oesophagus but reduced to a small ring on the upper side of the oesophagus.

Hancock, 1859, says that the nervous system is easily seen but not clearly defined. In one form studied five centers of nervous tissue were found about the oesophagus, three of which were large enough to be called chief ganglia. He did not find a pallial nerve described by Owen.

Van Bemmelen, 1883, has a more detailed account of the nervous system. According to this author there is a pair of infra-oesophageal ganglia and two true supra-oesophageal centers. From both, nerves run to the arms. The nerve centers are composed of very small ganglion cells and fibers; the peripheral nerves are composed of straight fibers.

Beyer, 1886, describes a commissural ring surrounding the oesophagus at its junction with the stomach, in *Lingula*. There are nerve centers in the ring as follows: one central, two dorso-lateral and two ventro-lateral, these last being the largest. All centers are below the ectoderm and the nerve cells communicate with the surface.

Blockmann, 1892-3, gives quite a complete picture of the distribution of the ganglia and chief branches. In his work the lateral ganglia are widely separated and little emphasis is given to any supra-oesophageal center.

Delage and Herouard, 1897, give quite an extensive account of the nervous system. In their general account they speak of a simpler nervous system presuming to some extent embryonic conditions of connection with the epidermis. There is a large peribuccal collar formed of two dorsal cerebral ganglia and a ventral ganglion much larger and a little bilobed, with a pair of fine connectives. From the cerebral ganglia nerves go to the arms. From the extremity of the connectives a pair of nerves run to the cirri. Nerves in the arms anastomose and form a plexus of fibrous cells just under the epidermis. The ventral ganglion gives off, at its posterior angle, a pair of dorsal pallial nerves which run to a corresponding

lobe of the mantle. From the anterior angle a ventral pallial nerve soon branches into two, one for the dorsal lobe of the mantle and one for the corresponding adductor muscles. It is probable that these nerves also go to the muscles and viscera. In the ventral region is a plexus formed by the ventral pallial nerves. In the mantle the pallial nerves form a plexus with ganglion cells.

There are no positive organs of sense; there are neither eyes nor otocysts. Probably the margins serve as organs of touch. The cirri are probably for tactile sense, possibly olfactory. They have a rich nerve plexus.

Stomach papillae Joubin, 1886-92, suggested as gustatory, and the terminal papillae of the mantle Sollas, 1887, believed had a tactile function.

In Ecardia, Delage and Herouard give a separate account. A single pair of ganglia are situated very low and at the external

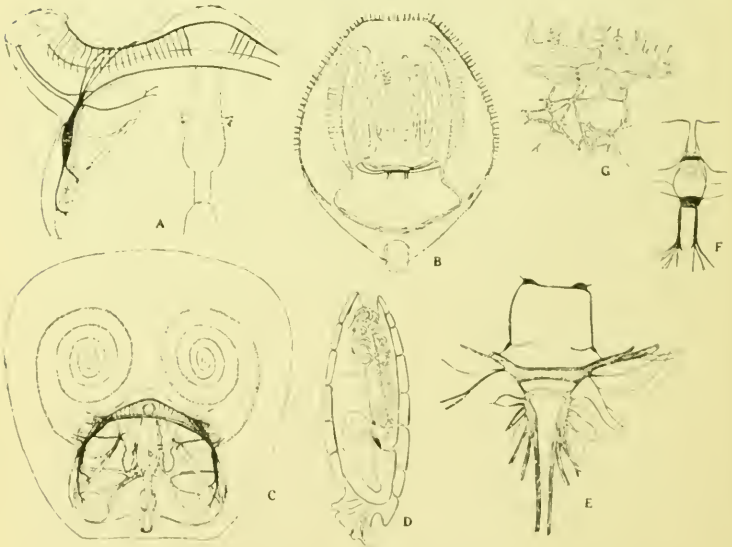


Fig. 23. Nervous System of Brachiopoda. A. Diagram of the nervous system from the ventral side showing the ganglion and chief nerves after Blochmann. Much modified. B. Diagram of the nervous system of a brachiopod, after Brammelen. C. Position of the nervous system shown in position. Diagrammatic. D. Diagram of *Lingula* showing ganglia in dark. E. General plan of the nervous system. F. Plan of the central nervous system. G. Nerve plexus.

border of the superior adductor muscles. A large ventral commissure unites the ganglia under the oesophagus. Each ganglion furnishes the following nerves: (1) to the adductor inferior muscle, a nerve with a little branch to the internal oblique muscle, (2) a nerve to the dorsal part of the mantle, (3) a nerve to the ventral part of the mantle, (4) a nerve to the arm, (5) branches which join with the ventral oesophageal commissure, (6) several nerves forming the dorsal nerve commissures. The dorsal commissure has nerves going to the cirri.

All nerves are under the skin. Cirri are probably organs of touch.

Heath, 1889, has found sensitive striae formed by high epithelial cells connected with the ganglion cells. These areas are along the middle line on the ventral side.

In spite of fragmentary and conflicting evidence the following seems clear as the nervous system of brachiopods:

A nerve ring surrounds the oesophagus; this is enlarged on the dorsal side in a small inconspicuous ganglion near the base of the lip. A larger suboesophageal ganglion is the thickening on ventral side. The ventral ganglion and perhaps the dorsal retain their primitive connections with the surface layer of the skin. Both ganglia give off a nerve each side to the arms and along the base of the tentacles and lips. The ventral ganglion also gives off nerves which supply the dorsal and ventral folds of the mantle and the muscles. In some cases the dorsal ganglion seems to be represented by a dorsal band only.

Sense organs are doubtful; the margins of mantle and cirri may have a tactile function and the epithelium on the surface of the ganglia have been suggested as olfactory areas.

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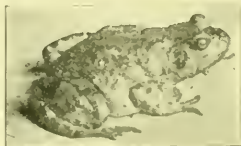
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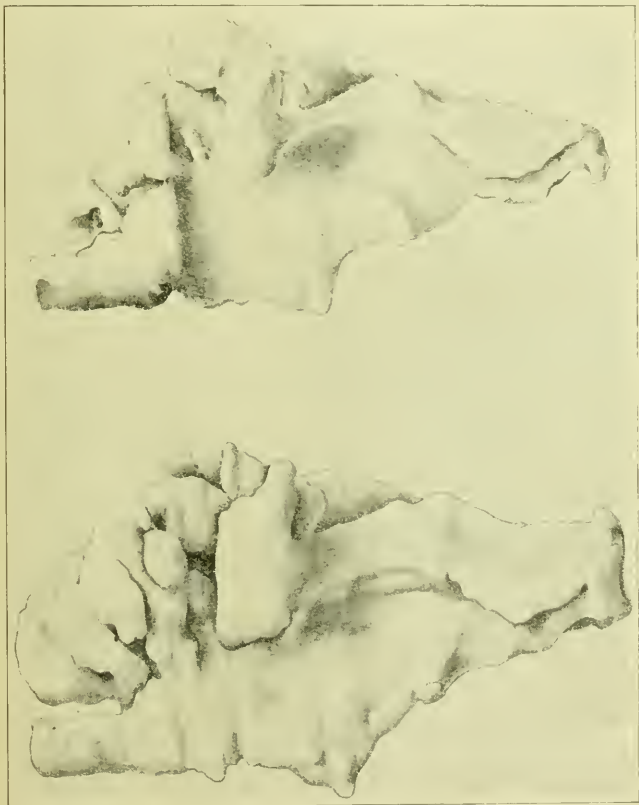
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A Model of the Nasal Chamber of a White Mouse at Birth

Ida Merrill and Eugenia Schoonover

Two models were made by the blotting paper method. In one of these the outer portion of the epithelium was taken as the outer limit and the lining of the cavity as the other. The other model was built from the plates which were cut from the interior of the



Upper figure model of the cavity, from outside.

Lower figure model of epithelium from outside. Both figures X40.

model. The larger model gives a picture of the mucous membrane and the nasal chambers, the smaller shows the shape of the nasal chamber. The knob on the inner side of the larger model is Jacobson's organ. The drawings are by Elizabeth Keyes.

(Contribution from Zoological Laboratory of Pomona College.)



Upper figure section of the model of epithelium.
Lower figure model of epithelium from the outside. Jacobson's organ, the little elevation in the lower center. X40.

The North American Species of *Mimetus*

By Ralph V. Chamberlin

In his "Araneides of the United States," Hentz describes three species under the genus *Mimetus*; namely, *interfector*, *tuberosus* and *sylllepsicus*. Of these three *sylllepsicus* has not since been definitely identified, while *tuberosus* is generally regarded as a synonym of *interfector*, a disposition with which no fault can be found. In 1882 Emerton described a male from Connecticut under the name *M. epeiroides*; but the practice in recent years has been to refer all individuals of the genus found in the United States to one species, *interfector*, and, accordingly, in current catalogues *epeiroides* has been placed in synonymy with that species.

However, a careful study of ample material of *Mimetus* from various parts of the country reveals that there are at least five clearly distinct species that have been confused under the name *interfector*. One species occurs on the Pacific Coast apparently from Washington to southern California and eastward to Texas. Two species occur in the Northeastern States, the commoner of these ranging southward as far as northern Georgia. The other two species are common in the Southern States; and one of them is found as far northward as Long Island, N. Y. It seems reasonably certain that it was one of these two southern forms that was described by Hentz as *interfector*, the particular one being fixed, it is believed, by the figure of the palpus as indicated later in the notes on the species. *Tuberosus* is left as a synonym of *interfector*; but *sylllepsicus* cannot be placed at present and is apparently different from any of the five species here listed.

The males of these five species are easily recognized by the characters presented in the palpus, the armature of the ectal margin of the cymbium providing a convenient index. Another readily observed character of diagnostic importance occurs in the terminal portion of the bulb which in the retracted organ lies adjacent to the base of the embolus and presents typically two flat or lamellar lobes projecting proximad. In one species (*notius*) one of these lamellar lobes is aborted and in another (*puritanus*) the second lobe is itself partly divided or bilobed.

The four species of which females are known may be separated in that sex by the characters of the epigynum, which is in the form of a strongly chitinized, transversely furrowed, caudally projecting lobe. At the caudal end of the epigynum, or near it on its dorsal side, is an opening or pit and cephalad or proximad of this on the dorsal side is a separately chitinized median longitudinal piece or strip. The position and form of this epigynal opening or pit, the size and position of caudal end of the median dorsal strip,

and the form and position of the spermathecae as revealed in cleared specimens furnish good diagnostic characters.

Adults of the species here listed may be identified by means of the following keys in conjunction with the accompanying figures of palpi and epigyna.

Key to Males

- a. Ectal margin of cymbium of palpus with no chitinous, spiniform process proximad of the curved or bent apical one.
- b. Ectal border of cymbium with an elevated and sharply limited lobe at caudal end of scabrous portion of margin, the surface of the lobe covered with minute prickles; bulb with two apical lamellar lobes (Fig. 5) *M. interfector* Hentz
- b.' Scabrous portion of ectal margin of cymbium not ending caudally in any such sharply defined lobe; apical portion of bulb bearing only one developed lamellar lobe, the ectal one being aborted and at most represented by a minute tooth (Fig. 4) *M. notius* sp. nov.
- a.' Ectal margin of cymbium with one or two chitinous processes or spines proximad of the apical one.
- b. With only one spine on margin of cymbium proximad of the apical one, this toward the base; border scabrous from apical to basal spine (Fig. 3) *M. epeiroides* Emerton
- b.' With two spines on ectal border of cymbium proximad of the apical one of which the more distal one is sometimes weak; margin scabrous only from apical spine to the more distal marginal one.
- c. Proximal marginal spine contiguous, or nearly so, with basal lobe or auricle of cymbium; apical portion of bulb with neither lamellar lobe at all subdivided or presenting processes (Fig. 2) *M. hesperus* sp. nov.
- c.' Proximal marginal spine well removed from basal lobe of cymbium; apical portion of bulb with the larger, more mesal, lamellar lobe partly subdivided, being extended at its mesodistal corner (Fig. 1) *M. puritanus* sp. nov.

Key to Females.

- a. The opening or pit located at extreme caudal end of epigynum and visible in ventral view, the end in this view appearing notched at the middle; median dorsal strip extending nearly to caudal end of epigynum. *M. puritanus* sp. nov.
- a.' The pit is on the dorsal surface just proximad of caudal end of

epigynum and thus not visible from below, the end not appearing notched at middle; dorsal strip ending considerably proximad of end of epigynum.

b. Opening with no tooth or process from each lateral margin, not thus partially subdivided; spermathecae essentially longitudinal; dorsal strip broader (Fig. 10).....*M. notius* sp. nov.

b.' Opening partly divided into a distal and proximal portion by lateral processes; caudal portion of spermathecae bent at right angles, a distinct enlarged anterior and posterior portion being connected by a narrower isthmus; dorsal strip narrower.

c. Lateral margins of epigynum not indented; isthmus of of spermathecae narrower, curved, concave ectally.*M. interfactor* Hentz

c.' Lateral margins of epigynum indented near level of caudal ends of spermathecae; isthmus of spermathecae thick, straight (Figs 7 and 8)....*M. hesperus* sp. nov.

Mimetus hesperus sp. nov.

In the male of this species the ectal margin of the cymbium of the palpus bears two conspicuous black spines proximad of the apical curved one as in *puritanus*; but in the present species the more proximal of these spines is in the re-entrant angle above basal lobe or auricle, whereas it is distinctly distad of this position in *puritanus*. A readily noted difference in the bulb is that the larger lobe at apex of bulb is entire in *hesperus*, with no separate process from inner distal corner as in the eastern form; and between this lobe and the conductor there are two folds of conical outline not present in the latter species (Cf. fig 2). The female differs conspicuously in not having the epigynal opening terminal and thus producing a median notch when viewed from below. The epigynum in its structure most resembles that of *interfactor*, but differs in outline and in the form of the spermathecae (Cf. figs. 7 and 8).

Type Locality.—California: Claremont. Type, a male, M. C. Z. No. 530.

Other Localities.—California: Stanford; Washington: Camp Umatilla; Utah; Texas: San Antonio, Austin.

Mimetus puritanus sp. nov.

Mimetus interfactor Emerton (nec. Hentz), Trans. Conn. Acad. Sci., 1882, 6, p. 16, pl. 3, fig. 3.

Mimetus interfector Keyserling (in part, including those figured), *Spinnen Amerikas*, Theridiidae 2, 1886, p. 6, pl. 11, fig. 137.

This species is in the female sex at once distinguishable from all the others in having the epigynal pit at the caudal apex and visible as a median notch from below (Fig. 6). The male may be separated from the other species occurring in the eastern and southern States by the presence of two subapical spines on the ectal margin of the cymbium; and from the western *hesperus*, as indicated above, by the position of the more proximal of these spines and the form of the larger lamellar lobe of the bulb, which is unlike that of any other species (Fig. 1).

Type Locality.—New York: Ithaca. Type, M. C. Z. No. 535, a male.

Other Localities.—New York: Long Island, Sea Cliff; Maine: Ogunquit; Mass.: Ipswich, Plymouth; Conn.: New Haven; Virginia: Great Falls, Falls Church; Georgia: Thompson's Mills.

Mimetus cpeiroides Emerton

Trans. Conn. Acad. Sci., 1882, 6, p. 17, pl. 3, fig. 4.

Known only from the male which is clearly distinct from the other species in characters of the palpus. In this the ectal margin of the cymbium possesses a single spine toward the basal lobe, in distinction from the two preceding species in which there are two spines on the margin, and from the two following ones in which there is no marginal spine proximad of the distal one. The ectal border is scabrous over its entire length from apex to basal spine. The terminal portion of bulb bears two lamellar lobes, both of which are simple.

Type Locality.—Mass.: Essex.

Immature specimens referred to this species have also been taken by Mr. Emerton at other places in eastern Massachusetts and at Providence, Rhode Island.

Mimetus interfector Hentz

Journ. Boston Soc. Nat. Hist., 1850, y, p. 3, pl. 4, fig. 12, 13.

Mimetus tuberosus Hentz, *ibid.*, p. 3, pl. 4, fig. 14.

Of each of the two species of *Mimetus* occurring commonly in the southern States, individuals may be found which match the figures of *interfector* given by Hentz reasonably well. I believe the species to be fixed, however, by the figure of the palpus of the male which, in spite of its general inadequacy, shows two prominent lobes projecting proximad from the bulb that are apparently the two lamellar lobes present in the one species, whereas in the other species, listed below as *M. notius*, sp. nov., there is but a single

lamellar lobe. In the species thus considered to be fixed as the true *interfector* of Hentz the ectal margin of the cymbium lacks spines; the scabrous border ends proximally abruptly in a lobe elevated above the general surface and on which the area of prickles is broader, a very characteristic feature enabling one to detect the species at a glance (Fig. 5). The form of the opening of the epigynal pit is similar to that of *hesperus*, being partly subdivided by a projection from each lateral margin and thus differing from that of *notius*. The spermathecae also present a caudal and an anterior larger lobe connected by a narrower, weakly curved, isthmus.

Type Locality.—Alabama.

Other Localities.—Alabama: Morgan, Birmingham; Georgia: Atlanta; Louisiana: Shreveport, Covington, Shrewsbury; North Carolina; New York: Sea Cliff.

Mimetus notius, sp. nov.

In this species the opening of the epigynum lacks projections from its lateral margins, and the median dorsal strip is broader and more conspicuous than, e. g., in *M. interfector* or *M. hesperus*; the spermathecae are essentially longitudinal as shown in fig. 10. The male differs from all the others here considered in having on the distal portion of bulb of palpus only a single lamellar lobe, the ectal one being absent or represented only by a slight tooth at base of the developed lobe. The ectal margin of the cymbium lacks spines proximad of the apex and its scabrous border runs out gradually, not ending in any such abruptly elevated lobe as occurs in *interfector*.

Type Locality—Runnymede. Type, a male, M. C. Z. No. 551.

Other Localities.—Florida: Altoona, Daytona; Louisiana: Shreveport, Mansura; North Carolina: Raleigh.

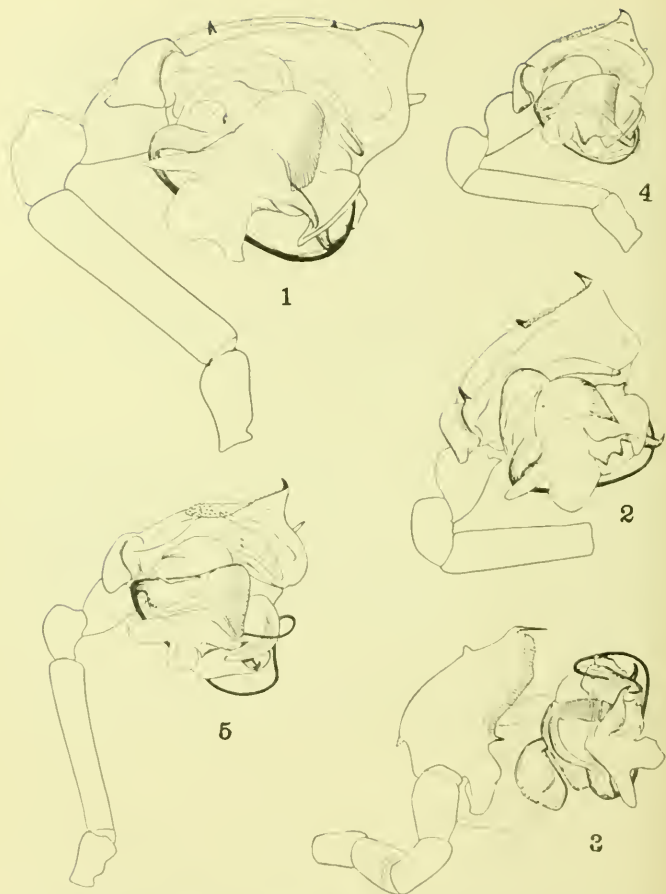
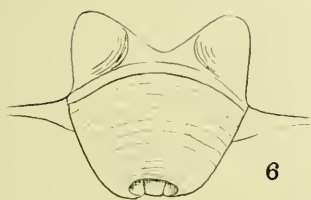


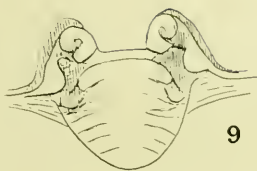
Fig. 1. *Mimetus puritanus* sp. nov. Right palpus of male, subectal view. 2. *M. hesperus* sp. nov. Right palpus of male, similar view. 3. *M. epeiroides* Emerton. Right palpus of male (type) from a more dorsal aspect, the hematodocha distended. 4. *M. notius* sp. nov. Right palpus of male, subectal aspect. 5. *M. interfector* Hentz. Right palpus of male, subectal aspect.



6



7



9



10



8

Fig. 6. *Mimetus puritanus* sp. nov. Epigynum, ventral view. 7. *M. hesperus* sp. nov. Epigynum, ventral view. 8. *M. hesperus* sp. nov. Epigynum viewed from above by transmitted light, showing opening, dorsal strip, and the spermathecae in silhouette. 9. *M. interfector* Hentz. Epigynum in ventral view. 10. *M. notius* sp. nov. Epigynum viewed from above by transmitted light to show form of opening and of dorsal strip and the spermathecae in silhouette.

XII. Enteropneusta

For our general knowledge of the central nervous system of this group we have the papers of Spengel, 1884-1894, Bateson, 1886.

Of the development of the nervous system and the larvae the work began in 1870 with the study of the so-called Tornaria larvae. Bateson, 1884-5, worked out the life history of a *Balanoglossus* form and later Spengel, '94 and Morgan, '91 and '94 gave an extended account of the Tornarian forms, including a good account of the nervous system. Ritter, '94 and Davis, '08, gave stages in the development of Tornaria and *Dolichoglossus*, and Herder, 1909, also gave an account of development in which the nervous system was included.

In various accounts of the position and structure of the nervous system especially as summarized in text books and other places, there seems at times to be some difference in the descriptions but I think for the most part the differences are in the way of expressing much the same idea so that no real difference is introduced.

In all cases the nervous system is as a whole epidermal much as in *Phoronis* and in starfish. The epithelium everywhere is more or less made up of columnar cells at the surface with a deeper nervous layer of fibers, in part branches from the surface cells, and a few deeper cells. In places the epidermic nervous system is more marked. The whole body then might be described as covered with a plexus of nerve cells and fibers; the thicker parts of the plexus in places form the so-called nerves. The chief nerves of this sort are a dorsal and ventral tract in the body region below the collar with a circular band connecting these at the lower edge of the collar, and a concentration of fibres about the base of the proboscis, but the greater concentrations are in the collar itself. In the dorsal and ventral surfaces of the collar just under the epidermis is a concentration of nerve cells and fibers but the chief and central concentration of nervous tissues is in the form of a thicker cord running through the cavity of the collar on the dorsal side, although connected with the epidermis at each end. This central nervous system is continuous with the proboscis thickening in front and as just described, with the dorsal and circular nerve tracts behind.

To summarize, the nervous system may be described as follows:

1. General epidermal plexus continuous with other parts.
2. Basal proboscis ring continued into the proboscis by a more diffuse band.
3. Ventral body nerve continued into ventral collar as a thin layer.

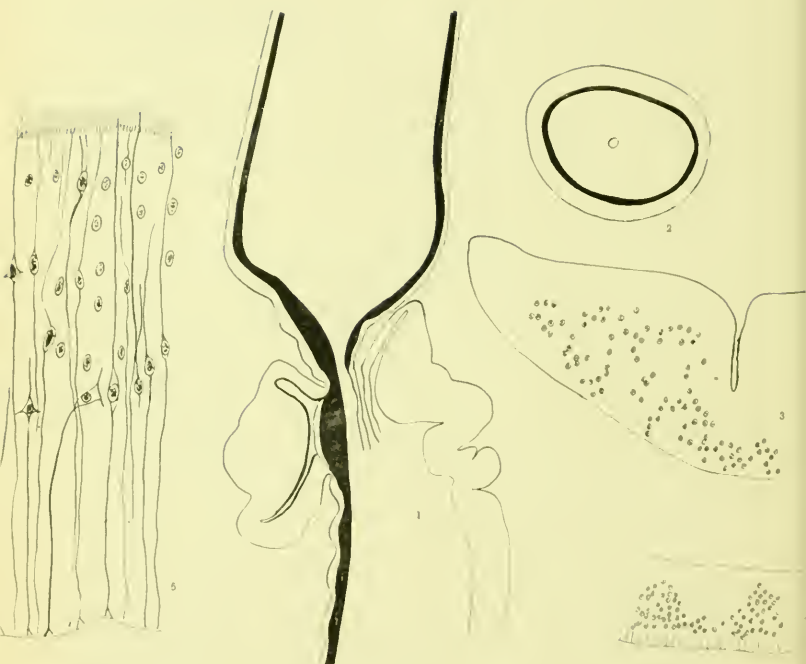


Fig. 25. Diagrams to show the position of the nervous system in *Dolichoglossus*. Nervous system shown by heavy lines below the surface.
 1. Longitudinal section. 2. Cross section through the proboscis.
 3. Central portion much enlarged. 4. Another part of the surface.
 5. Neural epithelium much enlarged.

4. Dorsal collar nerve somewhat cut off from the two following.

5. Dorsal proboscis nerve continued above.

6. Central nervous system running through the central region of the collar on the dorsal side and continuous above with the proboscis nerves and below the collar with the dorsal body nerve.

The dorsal nerve of the collar and the thick central nervous system of the collar are more or less joined by the strands and they together make a sort of nerve tube thin on the dorsal side but thick below.

The histological structure of the nervous system reveals besides the usual epithelial cells of the surface, bipolar supportive

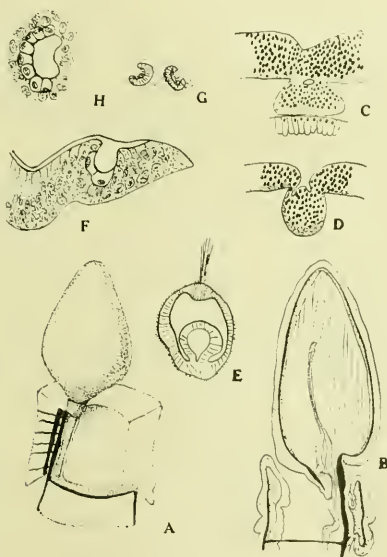


Fig. 24. Nervous System and Sense Organs of Enteropneusta. A. Diagram of *Balanoglossus* showing position of the nervous system. B. Another diagram of *Balanoglossus* in sectional view. Spengel. C, D. Sections of developing nervous system. Morgan. E. Larva after Herder. F. Apical eye of tornaria larva. Spengel. G. Eyes of Tornaria after Morgan. H. Eye of Tornaria after Spengel.

cells reaching from the surface to the depths of the nervous system and also probably bipolar sense cells as well as more or less deeply placed multipolar nerve cells giving off fibers to the nerve areas.

The epidermis is a general organ of sense, the exact nature of which has not been very clearly determined. Spengel considers that about the proboscis in its ventral face there are points especially sensitive. In fact at this place he describes a deep depression which he regarded as a special sense organ.

In the larval stage the first suggestion of a nervous system we find in the development of the apical plate which in later stages develops eye spots as simple caps of ectodermal cells surrounded by pigment. The eye spots become anterior in position with a pocket of the clear cells each ending in a point. Between the two eye-cups a mass of pigment develops. At the base of the apical plate nerve fibers begin to be seen.

At metamorphosis in a region where the collar will develop a transverse groove forms near the mid-dorsal line. In the mid-dorsal region a strip of ectoderm not crossed by grooves makes the beginning of the neural plate. It sinks beneath the surface and folds of the adjacent ectoderm or neural folds meet over it, and in this way the neural tube is formed.

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XIII. Cephalodiscus and Rhabdopleura

CEPHALODISCUS. The first report on this animal including a sketch of its anatomy was by McIntosh, 1887, and later by Lang, 1890, and Harmer. Delage and Herouard, 1897, summarize the knowledge of the nervous system about as follows:

The nervous system is a thickening of the epidermis on the dorsal surfaces of the tentacles. The histological nature of the nervous system was a little studied, but cells and fibers under the epithelium as in echinoderms were described.

Mastermann, 1903, describes the central ganglion over the sub-neural blood sinus; its position is as in *Actinotrocha*. This gives off below a pair of large nerves each of which divides into six branches for the six pairs of tentacle arms. Above it is prolonged



Fig. 26. A. *Cephalodiscus* showing location of the nervous system after Hammer. B. *Cephalodiscus* after Masterman. C. *Rhabdopleura* showing position of nervous system after Delage and Herouard.

into two large branches which follow the dorsal line of the epistome. Laterally from the ganglion two other nerve branches go to the epistomal disc. On the ventral surface of the trunk is a medial longitudinal band which is continued into the peduncle. According to Mastermann the mid-dorsal and two lateral epistomal branches have homologues in *Balanglossus* and *Actinotrocha*.

RHABDOPLEURA. The account of the structure of *Rhabdopleura* which is usually given is that of Fowler, 1892. Other accounts which however give little of the nervous system are those of Allman, 1869, and Lankester, 1874.

The central nervous system is represented by a thickening of the ectoderm in the median region of the neck below the nuchal pore between the branches of the tentacles. There is a differentiation of nervous tissue much as in *Rhabdopleura* or *Balanoglossus*. A black pigment spot is located at the tip of the preoral lobe and may be an eye-spot.

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Notes on the Early Stages of the Syrphid Genus *Microdon* (Diptera)

By Frank R. Cole, Stanford University

The peculiar larvae of the Syrphid flies of the genus *Microdon* have been described by several entomologists, but they are known in only a few species. Enthusiasts in past years placed these bizarre forms among the molluscs in two or three instances, and one entomologist stated that they were the early stages of a Coccid on oaks. Wheeler has given a very interesting account of some of these early stages and the habits of the flies. In America the larvae are recorded only from ants nests, but Wasmann states that they may be found in the nests of certain wasps and termites. They live in nests in the soil, under rocks or under the bark of old logs.

The larvae creep very slowly, with a wave-like motion of the flat ventral sole, which is fringed and applied closely to the surface over which they are travelling. Their food is probably, as Wheeler believes, the minute pellets of food ejected from the hypopharyngeal pockets of worker ants after the moisture has been extracted. There is evidently one brood in a year, the flies emerging in May and June.

In May, 1917, the writer found a number of pupae of *Microdon cothurnatus* Bigot, while collecting in the Hood River Valley of Oregon. The type of this species came from "Mt. Hood," probably somewhere in the valley north of the mountain. While pulling off the bark from an old pine log an ant's nest was uncovered, and among the frenzied inhabitants of the nest a number of *Microdon* pupae were noticed. The ant was later determined as a subspecies of *Camponotus maculatus*. At this date, May 19, there were no larvae of the fly present and the pupae were all fully developed. Eighteen pupae were taken, most of them rather closely crowded near the entrance to the nest; all around them were empty puparia, bearing evidence that the nest had been used for several seasons by the flies. There were several adult flies around the log, some of them freshly emerged, but the ants were so aroused at the disturbing of their domestic tranquility that they quickly drove out any strange insect that came near. The puparia taken were allowed to become too dry and only two adults emerged out of the lot.

In April, 1921, some observations were made on another species of *Microdon*. A student at Stanford University, Mr. Herbert Mason, found a single larva in a nest of *Camponotus maculatus vicinus* Mayr. This specimen was reared by Mr. Carl Duncan and the specimen and notes regarding it kindly turned over to the writer. The species proved to be *Microdon piperi* Knab, a beautiful dark blue species which ranges north along the Pacific coast region.

The larva was not closely examined by the writer, but in the notes made on the specimen the color was given as largely pale

bluish green, with median ridge and the margins of the body brown. The median ridge was quite prominent in the larva. The coarse reticulum on the body has a pattern somewhat like that figured for *M. tristis*, as can be seen from the figure. The length was 11 mm.

The puparium shortens to about 9 mm. The reticulum is much more distinct than in the larva and two prothoracic tubercles push out (in the specimen described one of the tubercles did not push through the body wall). The reticulation is arranged in a more or less symmetrical design and when examined under a high magnification is seen to be made up of two types of processes; those on the dorsal ridge and along the sides just above the fringe are of a shape which might be likened to an inverted wine glass and the other processes are quite short and composed almost entirely of the white stalked portion (see figs. 6 and 7). The base in both cases is dark brown and the apical portion white. From above the body appears to be covered with white discs arranged in a reticulated pattern, the center of each disc with a depression and a minute cavity which appears to penetrate almost or quite through the body wall. These minute structures may function as pores. The anterior margin of the ventral fringe of the body is deeply notched in the middle as shown in figure 4. The structure of the marginal fringe is shown enlarged in figure 8. The fly emerges from the puparium by breaking off the cover in three rather symmetrical pieces, illustrated in figure 2.

The specimen described was taken the last of March and soon commenced to pupate, the puparium being fully colored by April 8. The adult emerged just a month later.

Wheeler notes that the most typical and frequent hosts of the *Microdon* larvae are ants of the genus *Formica* but Wasmann has recorded a species of *Camponotus* in Madagascar as a host.

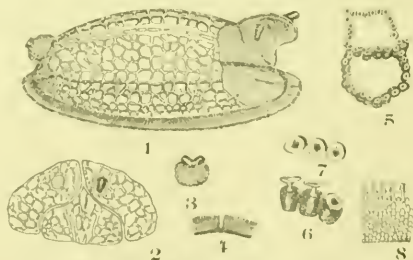


Fig. 1. Puparium of *Microdon pipri* Knab; 2, anterior portion of puparium, showing symmetrical breaking; 3, posterior respiratory tubercle; 4, marginal fringe of puparium, showing split in anterior region; 5, reticulations of two kinds, those with a short, and those with a high base; 6, and 7, portions of the reticulations more highly magnified; 8, marginal fringe, greatly magnified.

Notes on California Bombyliidae with Descriptions of New Species

Frank R. Cole, Stanford University, Cal.

The sun-loving Bombyliidae have always been a favorite group with the writer, as the rather abraded specimens in his earliest collections will bear evidence. California is rich in species of these flies and notes on a few of the interesting forms are given below.

During the past two summers the writer has spent some time in Mill Creek Canyon in San Bernardino County. *Paracosmus morrisoni* O. S. is a very common form in this locality and is usually taken along roads and paths in the bright sunlight. *Aphobantus vittatus* Coq., a trim, beautifully marked little species, occurs along with the above, but is not so common and is often harder to catch. *Villa squamigera* Coq. and *Villa mira* Coq. are not uncommon in the Mill Creek region, the latter species more abundant in August, when it is found out in the sandy river washes. *Villa miscella* Coq. is seldom seen and is quite wary, flying up and down sandy roads for long distances when disturbed. In Glen Martin, in this same general region but at a higher altitude, one occasionally finds *Rhabdoselaphus setosa* Cresson, a little species with a very long proboscis; it is usually taken on the wing in the middle of the day, hovering near the ground. With the first days of autumn specimens of *Villa autumnalis* Cole begin to appear, frequenting the yellow flowers of *Eriocameria* and *Chrysothamnus*, and now and then a specimen of the beautiful golden *Lordotus diversus* Coq.

Villa chromolepida new species.

Female. Length 7 mm. Black, clothed with bright iridescent scales; front tibiae without bristles; wings hyaline.

Head rather large in proportion to the body; proboscis pointed and scarcely projecting beyond the oral margin; palpi small, black, cylindrical and black pilose. Antennae black, first joint about twice as long as second and with black pile; third joint twice as long as first two combined and gradually tapering toward apex (see fig. 9), the apical bristle minute. Frons shining black, with erect black pile and sparse golden scales which are purple in certain lights. Face projecting (see fig. 10), shining black, with scales like frons but denser, pile short, black, reclinate. Cheeks shining black, bare of pile or scales. Occiput black, densely clothed with scales like those on face and frons; next the hollowed out back of the head a line of short, fine, yellowish pile.

Mesonotum and scutellum shining black, with golden green scales, purple by reflection; the median portion of dorsum with

erect blackish pile, the front and margins with white pile, stiff and erect just back of the head. Pile of scutellum sparse and white. Pleura shining black, with rather long, dense white pile on the upper mesopleura, the lower part of mesopleura and other pleural plates with sparse black pile, not obscuring the ground color; stiff, blackish bristle-like pile above front coxae. The coxae and pleura with a few scattered iridescent scales. Stem of halteres yellow, the knob white, with a black mark on anterior margin; tuft of pile before halteres largely yellow.

Abdomen black, with erect white pile on sides of first and on anterior corners of second segment; beyond this the pile is very sparse, black, reclinate and scarcely noticeable. On each side of posterior margin of first visible tergite some scales like those on thorax; on the other abdominal tergites and sternites there is a dense covering of tomentum or scales, largely colored like those of thorax and in a definite design on dorsum; in the center of each tergite beyond the first visible one a round spot with sparse black scales, on each side a larger oval spot covered with black scales which have a purplish color in some lights; these lateral spots missing on seventh segment, which is almost wholly covered with iridescent scales. The venter black, with a wide median portion clothed with black tomentum, the sides with iridescent scales as on the more or less telescoped, the last two segments scarcely visible; color of pollen and pile as in male. Apices of femora an ochre dorsum. Femora and bases of tibiae brownish yellow, the rest of legs black; all the spines and pile of legs black, front tibiae without bristles, the anterior tarsi with claws almost as large as on the other tarsi; femora with a few yellowish, iridescent scales and some black ones; tibiae and tarsi with black scales. Wings hyaline, iridescent; the costa and veins at base yellowish, toward posterior margin black; fork of radius rather angular at base. The epaulets with purplish iridescent scales.

Holotype, a female, collected in Mill Creek Canyon, Cal., July 20, 1920 (F. R. Cole), in the collection of the California Academy of Sciences.

The type female is the only specimen known and is not closely related to any species seen by the writer. In Coquillett's table of species it would run to *mercedis*. It is distinct from any described Mexican species.

Amphicosmus vanduzeei new species.

Female. Length 6 mm. A slender species, the body largely shining black, the legs yellow.

Upper two-thirds of frons black, including the large ocellar tubercle, the lower third yellow; pile sparse, fine, white, the narrow orbits silvery pollinose. Face short, projecting, the central portion shining black, sides yellow and with silvery pollen; antennal foveae

deep and connected; first antennal joint slightly longer than second, yellow; second and third joints black, the third joint about as long as the first two combined, narrower (see fig. 6), with a short sub-apical style. Vertex and upper occiput rather full (see fig. 7), black, the lower occiput and cheeks yellow, occiput largely silvery pollinose, the pile minute and whitish.

Mesonotum and scutellum shining black, the pile on median portion of mesonotum and on scutellum short, blackish, on margins of mesonotum white. Humeral callosities yellow, silvery pollinose; a silvery pollinose, white pilose spot just back of humeri. Prescutellar callosities partly yellow. Pleura shining black, the upper mesopleura, the metapleura and hypopleura silvery pollinose and white pilose. Halteres white.

Abdomen largely shining black, rather broad posterior margins of all segments yellowish; apical half of seventh visible segment lemon yellow; yellow on first segment reaches lateral margins, on the second to sixth segments it does not do so. Pile of abdomen very fine, sparse, white, longer on sides of first and second. Venter largely brownish yellow, blackish at base, lemon yellow on genitalia. Femora, tibiae, first tarsal joint, apex of fifth and base of claws honey yellow; third and fourth tarsal joints, apex of second and base of fifth blackish. Coxae and trochanters colored like femora, a black spot below on base of trochanters. Wings hyaline, all veins yellow at base, toward apex and posterior margin blackish. All cells on posterior margin of wing wide open (see fig. 8).

Holotype, a female, collected at Palm Springs, Cal., May 20, 1917 (E. P. Van Duzee), in collection of California Academy of Sciences. The type a unique.

This species differs from *elegans* Coquillett in having the first antennal joint yellow and in the greater extent of black on the abdomen. Coquillett gives no structural characters to distinguish his species. The above described species differs from *cincturus* Williston, from Mexico, in the smaller size and in the color of the antennae and legs, *cincturus* having entirely black legs.

Metacosmus nitidus new species.

Female. Length 5.5 mm. Head black, a small amount of yellow on sides of oral margin. Ocellar tubercle slightly above middle of frons but the lower ocellus nearly in the center; upper half of frons with white pile, the lower part with black; frons shining black, the narrow orbits silvery pollinose. Antennae black, rather short and thick, the second joint larger than first (see fig. 4). Upper face and lower frons near base of antennae silvery pollinose; face short, shining black, distinctly projecting. Occiput thinly gray pollinose, short, sparse white pilose; on the under side, back from mouth opening, an oval yellow spot on each side of middle. Proboscis not projecting beyond oral margin.

Thorax shining black, the dorsum with short, sparse white pile; scutellum shining black, with short white pile. Humeral callosities and lower half of pleura gray pollinose. Stem and under part of knob of halteres blackish, the most of knob white.

Abdomen shining black, finely punctate and with short, sparse whitish pile; hind margins of visible segments one to four narrowly yellowish white, broader on the first. Abdominal pile appears white in certain lights but is largely dark colored. Sternite of seventh segment projects downward in a noticeable triangle as seen in profile. Pile around genitalia rather dense and whitish. Venter black, the hind margins of first five segments yellowish white. Legs wholly black, the pile fine and short. Wings hyaline, rather broad and rounded, the veins black and strong; R2+3 curved slightly forward at tip (see fig. 3).

Holotype, a female, collected at Huntington Lake, Fresno County, California, 7000 feet, July 15, 1919 (E. P. Van Duzee), in the collection of the California Academy of Sciences.

Paratypes.—Two females, taken in the type locality, July 8, 1919, by Mr. E. P. Van Duzee.

This species is evidently near *M. exilis* Coquillett, but differs in the color of the legs and in the wing venation. The only other species in the genus is *manicipennis* Coquillett an eastern form, which has the face and the stems of the halteres white.

Acreotrichus maculipennis new species.

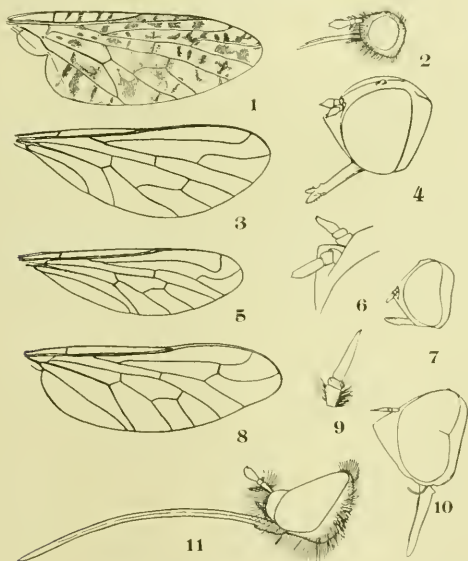
A velvety brown species with thickly spotted wings; the proboscis slightly longer than the head.

Male. Length 4.25 mm. Head black, brownish pollinose, the face and vertex with rather long and erect black pile. Occiput rather flat; occiput and cheeks with black pile. Oral opening large, the antennae placed on the upper edge (see fig. 2); first and second antennal joints rather slender, the first slightly longer than the second, the third slightly longer than the first two combined and considerably widened near the middle, the style short and subapical (see fig. 2); pile on upper side of all antennal joints black. Proboscis black, projecting twice the length of the antennae beyond the oral margin. Palpi black, very slender, with black pile, projecting beyond oral margin about one-third as far as proboscis.

Thorax black; mesonotum velvety black, shading to a sepia brown on the margins; the pile of dorsum erect and yellowish, appearing brown in certain lights. Scutellum velvety black, with comparatively long, coarse yellowish pile. There are indications of two median black vittae on the anterior part of the mesonotum, separated by a fine brown line. Pleura brown pollinose, the sparse

pile on mesa- and sterno-pleura brown. Stem of halteres yellowish, the knob yellow above and blackish brown below.

Abdomen black, sepia brown pollinose, with rather long, erect yellowish pile, nowhere dense enough to obscure the ground color. Venter like the dorsum, the pile shorter and more reclinate. Seventh visible segment projecting over the small eighth, the genitalia quite small, colored like the abdomen, the upper and lower forceps about equal in size and closing over the internal organs. Knees reddish, the rest of legs black; coxae and femora with long black pile. Wings whitish hyaline, densely maculated with dark gray and with remarkable thickenings of the membrane, some of which appear to form supernumerary cross-veins (see fig. 1). The veins near the posterior margin of the wing are wavy.



EXPLANATION OF PLATE

Fig. 1. Wing of *Acrotichus maculipennis* n. sp.; fig. 2, head of *A. maculipennis*; fig. 3, wing of *Metacosmus nitidus* n. sp.; fig. 4, head of *M. nitidus*; fig. 5, wing of *Paracosmus morrisoni* O. S.; fig. 6, antennae and front of head of *Amphicosmus vanduzeei* n. sp.; fig. 7, head of *A. vanduzeei*; fig. 8, wing of *A. vanduzeei*; 9, antenna of *Villa chromolepida* n. sp.; fig. 10, head of *V. chromolepida*; fig. 11, head of *Rhabdoselaphus setosus* Cresson.

Female. In general very much like the male but lighter in coloration. Pile of cheeks and lower occiput yellowish, on the rest of the head and on the antennae reddish brown. Eyes widely separated, the pollen of frons more buff colored than in male, the pile shorter. Pollen of mesonotum much lighter in color than in male, the pile shorter and paler. Ground color of coxae and pleura yellowish brown in some specimens, the pile yellow. Knob of halteres scarcely darkened below. Abdomen in dried specimens yellow, also the tibiae except apices and bases of the four front tarsi. Pile and fine setulae of femora and tibiae yellowish.

Holotype, a male, and *allotype*, a female, collected on the sand dunes near Golden Gate Park, San Francisco, Cal., September 10, 1920 (F. R. Cole), in the collection of the California Academy of Sciences.

Paratypes.—Two specimens in the Cal. Acad. of Sci., taken in the type locality, and five specimens in the writer's collection, taken with the types.

In 1895 Coquillett described *Aercotrichus americanus* from a single male specimen taken in the state of Washington. This little species has hyaline wings, the antennae are quite different and the proboscis comparatively longer. In May, 1917, the writer took a single male specimen of *A. americanus* near Hood River, Oregon; it appears to be a rare species. *A. atratus* Coquillett, from Mexico, has a slender third antennal joint, three times as long as the first two combined and of nearly an equal width; the wings are grayish hyaline. The three other known species in the genus are described from Australia.

Notes on the Color Changes of Frogs

Sarah Marimon

In all these experiments I chose two identical frogs, and kept one in normal conditions while the other was being subjected to change.

Tree frogs, *Hyla regilla*.

I. June 16. Hot water (about 30° to 35° C.). Left the frogs for one hour.

The spots of the frog faded out, giving a lighter appearance. However the background seemed much the same as the control.

Control. Tap water (about 15°-17° C.). Spots distinct. Grayish green frog.

II. June 17. Hot water. The frogs for this experiment had peculiar red and green markings.

The whole tone was lighter at the end of an hour and one-half. Spots somewhat more indistinct than at first.

Control. Color unchanged.

III. June 16. Cold water. (Cooled with ice—2° C.) The frog was somewhat darker in color; the spots stood out more distinctly than previously.

Control. Tap water (15-17° C.) Color unchanged, spots showing distinctly—not so distinctly as those of the frog in cold water.

IV. June 17. Cold water. a. The frogs were rather light in color. Darker spots more distinct.

b. Two frogs grayish green in color. The color became darker, spots more distinct.

V. June 17. 5:00 P. M. Two frogs with red streaks down the backs.

One jar covered with green tissue paper, the other left as a control.

June 18. 10 A. M. Lighter in tone than the control. The red streak changed to light sandy color. Spots lighter.—greenish along the sides.

Control. Same as the day before, apparently. Spots dark grey, grey sides, broad reddish streak down the back.

11 A. M. The frogs reversed.

June 19. Red streak narrower, sandy colored. The whole cast of the frog was lighter and more greenish.

Streak dark reddish. Frog much darker than the one in green jar.

VI. June 21. Green and cold. To see which has the greater effect, the background or the temperature.

a. Two frogs rather light in color.

The spots are more distinct but the whole color is lighter than the control.

b. Two frogs rather dark in color.

Slightly lighter. The dark colored frogs do not seem to change as readily as the lighter ones.

These experiments would seem to indicate the greater effects of the background. However there was some chance for error here, because (1) the experiment was only over a period of two hours, and (2) because the frogs objected to the cold water, and when they were not watched, they would climb up out of the water and cling to the side of the jar.

VII. June 17. I put two frogs in a jar lined with leaves. One frog very reddish, the other grayish green.

June 21. The grayish green frog much greener, lighter in tone.

The reddish frog much lighter in tone but still decidedly reddish in color.

June 23. The red frog still reddish.

The green background lightened it but did not change its color.

VIII. June 17. 5 P. M. Red cover to the bottle. Placed the frogs in the jars.

June 18. 10 A. M. Slightly darker. Control. Color unchanged.

June 20. a. About the same shade as the other frog (i. e. the control) only with a more reddish tinge. b. Distinctly lighter, and more reddish in color.

June 21. Frogs had each a sandy streak down the back.

The streak brighter reddish. The whole tone of the frog slightly darker than the control. The frogs reversed. Streak sandy colored.

June 22. Streak brightly reddish. Whole tone of frog much lighter. Streak sandy colored. Darker than the one in red.

VIII. (a) June 17. 5 P. M. Took two greyish frogs with no particular color showing. Placed one in a jar covered with yellow tissue paper. The other frog used for a control.

June 18. Much lighter than the control. Seemed to have a yellowish tinge. Spots faded somewhat.

Reversed the frogs.

June 19. Lighter, the spots more faded than when in the control. The difference between the two not so marked as on June 18.

June 20. Slightly lighter, more yellowish in tone. Results not so distinct.

VIII. b. June 21. Two frogs with reddish streak (June 20). The streak more yellowish, now has a distinctly yellowish tone. Spots lighter. Whole tone more yellow than control.

Reversed the frogs.

June 22. Yellowish in tone. Red streak now very yellowish. Spots lighter.

IX. June 17. 5 P. M. Two frogs, dark in color, with red streaks down the back. One in blue covered jar, one control.

June 18. 10 A. M. Frog much lighter than the control.

The red streak along the back now sandy colored, however, still with the reddish tint. Control color unchanged. Noticeably darker than the one in blue.

The frogs reversed.

June 19. Lighter, the red streak sandy colored, same width as before. Sides light grayish green. Whole tone lighter than the one in the control.

The frogs reversed.

June 20. Lighter in tone, more greenish tinge. The red streak now sandy, slightly greenish also.

I observed some pigment cells under the microscopes. The melanophores (black) were the most noticeable, although on close observation yellow and bluish grey pigment cells could be seen.

I stimulated the piece of skin with ice; in some cases the black cells seemed to expand and in others this could not be seen. Some such action, however, would be necessary to cause the darkening in color brought about by cold.

The stimulations with heat were somewhat less definite than with cold; however twice the contraction of the melanophores, due to a heat stimulus, was observed.

Left the two dead frogs for six hours. When I observed them again they were both remarkably lighter than they had been when they were killed.

I took a bit of their skin and observed it again. One portion was much lighter and had several isolated melanophores. I cooled this piece of skin with ice, then stimulated it with hot water. The pigment cells seemed to expand.

Conclusions:

1. The tree frog changes its color in response to heat, cold and changes in the color of its environment.

2. The frog does not actually change color so much as it gets lighter or darker in response to stimuli. There seems to be, however, some actual change in color.

3. The colors, blue, green and yellow cause the frog to get lighter in color. The results with red were so irregular as to suggest that the change might be due to some other agent than the color environment.

4. When there is a reddish color present, i. e., red streak, the red environment intensifies this coloration. When, however, there is no red color present the red environment does not develop it.

5. This same phenomena is true of green coloration. Thus a red frog does not seem to be able to change into a green one, nor a green frog into a red one.

6. The changes in coloration or intensity seem to be due to the expansion of the pigment cells.

Experiments with Rana sp.

I. May 26. Light. I left the frog in the light (sunlight, although not direct) for one hour. At the end of this time it was remarkably lighter than the one in the dark room.

II. May 26. Dark. Frog like the one in light. I left it in the dark room for one hour. At the end of this time it was much darker than the one in the light.

Reversed frogs.

Left two hours. At the end of this time the two frogs were the same color again.

May 28. Repeated the first step of the light and dark experiment with the same results.

May 29. Placed one frog on a white reflecting surface but not in the sunlight. In one hour very little change.

At the end of the hour, placed the frog in the sunlight, still on a white, reflecting surface. Remained there for one hour. At the end of this time it was very much lighter than the one in the semi-darkness.

Sunlight then has more effect than diffused light, or perhaps the difference is caused by the difference in temperature.

III. May 29. Placed one frog in a rather dark but not absolutely dark place, used rather as a control than as an experiment. Apparently it did not change color.

Left it for another hour. The supposition was that it did not change color in the second hour, since the first hour had no effect.

However at the end of the hour it was much darker than the one in the sunlight.

IV. May 27. Heat and cold. Placed a frog in water of 30° C., left it for an hour and one-half.

At the end of this time it was decidedly lighter.

Placed a frog in water of 3° C., left it for an hour and one-half. At the end of this time it was decidedly darker.

There was a great deal of difference in the color of the two frogs at the end of the experiment.

V. May 28. Frog in water 30° C. Left one hour. Much lighter than one in cold.

Frog in water 3° C. Left one hour. Much darker.

Reversed the frogs at 2:24 o'clock.

At 2:45, the two frogs had reached the same color.

VI. June 1. Frog in water of 30° C., left one hour. Much lighter.

Frog in water 3° C., left one hour. Much darker.

VII. May 26. Acid. Placed one frog in a weak acid (HCL) solution. Left for several hours. There seemed to be no change in color—possibly a little lighter than the control.

Control. Placed one frog in water, otherwise its environment was the same as the one in acid.

No change in color.

VIII. Alkali. Placed one frog in a weak alkali (NaOH). Left it for several hours. There seemed to be no change in color—possibly slightly darker than the control.

EXPERIMENTS WITH A LOCAL FROG

IX. *Rana draytonii*

May 27.

X. Cold 3° C. Found a frog among the others identical in color.

Left in cold for one hour. Darker at the end of this time in comparison with the control.

XI. May 29. Light. Placed *Rana draytonii* in sunlight for an hour and one-half. At the end of this time it was very much lighter.

Control. Kept the control in semi-darkness. Did not change color.

Conclusions:

1. These frogs change color under certain conditions of heat, cold, light, dark, or excitement. Acids and alkalis have little if any effect.

2. a. Heat and light cause the frog to lighten in color. There is evidence that heat is the true agent, and light only as it is associated with heat.

b. Cold and dark cause the frog to darken in color.

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Notes on the Lepidoptera of Southern California. No. 1

DONALD C. MEADOWS

Two days during the second week of April 1922 were spent collecting Lepidoptera at Corn Spring, Chuckawalla mountains, Riverside county, California. The Chuckawallas are typical Colorado desert mountains, being low and rough, and having the vegetation for the most part confined to sandy washes. Corn Spring lies on the north side of the range in a canyon of the same name. It is a small palm covered oasis having many introduced plants as it is the home of an old prospector, who has a house and garden at the spring. The elevation is approximately 1500 feet.

Fourteen species of butterflies were collected and three observed. The nomenclature used is that of Barnes and McDunnough's Check List.

1. *Pieris protodice*, form *vernalis*—Edw. Three males and two females taken. Fairly common around spring.

2. *Nathalis iole*—Bdv. Five males collected. Found sparingly flying over bare, windswept desert mosaic. One specimen taken near mouth of Corn Spring canyon far from any vegetation.

3. *Eurymus eurytheme*, form *keewaydin*—Edw. Two males and two females taken. Common near spring.

4. *Danais archippus*—Fabr. One specimen seen at spring.

5. *Danais berenice*—var. *strigosa*—Bates. One specimen seen with the above flying among the palms at Corn Spring.

6. *Melitaea Neumoegeni*—Skin—Wright. Fourteen males and five females of this interesting species were taken. Probably the most common butterfly of that locality.

7. *Chlosync californica*—Wright. Nine males and five females taken in a small canyon about two miles above the spring. These butterflies seemed to be very local in their distribution, one small canyon being the only place that they were found. Types figured by Wright from specimens taken in Colorado Desert, Southeastern California. The Chuckawallas are at the northern edge of the type locality.

8. *Vanessa cardui*—Linn. A few specimens seen flying in Corn Spring canyon.

9. *Apodemia mormo*—Feld. One female taken.

10. *Apodemia virgulti*—Behr. One male taken flying with the above. Contrary to expectations these two species were not as common as in other parts of the desert.

11. *Calephelis nemisis*—Edw. One male and two females taken in canyon about two miles above spring.

12. *Atlides halesus*—Cramer. One female taken. Only one other seen flying around a species of mistletoe.

13. *Brephidium exilis*—Bdv. Few Lycaenidae were found. Two *B. exilis* were taken flying over grass growing near spring.

14. *Hemiargus hanno*—Stoll. Two males taken near spring. This is a Mexican butterfly and only occasionally reported from California.

15. *Hemiargus isolata*—Reak. A male taken in canyon above spring.

16. *Pyrgus tessellata*—Scud. A common butterfly throughout desert. Very common around Corn Spring.

17. *Thanaos clitus*—Edw. Another common species in vicinity of spring. A very fast flyer and difficult to catch. Six specimens taken.

In all sixty seven specimens were taken near the spring.

A List of Coleoptera Collected on the Beach During the Summer of 1921 at Laguna Beach, California

CLIFFORD T. DODDS

Determined by Dr. E. C. Van Dyke of the University of California.

CICINDELIDAE

Cicindela trifasciata Fab. var. *sigmoidea* Lec.

CARABIDAE

Dyschirius marinus (Lec.)

Bembidion ephippigrum (Lec.)

Bembidion indistinctum Dej.

**Bembidion cautum* (Lec.)

Platynus californicus (Dej.)

HYDROPHILIDAE

Ochthebius interruptus Lec.

‡*Cercyon fimbriatus* Mann.

STAPHYLINIDAE

Bledius fenyesi Bnhr.

Cafius canescens Makl.

‡*Cafius lithocharinus* Lec.

‡*Cafius luteipennis* Horn.

Thinopinus pictus Lec.

‡*Hadrates crassus* (Mann.)

Baryodma sulcicollis Mann.

HISTERIDAE

‡*Acritus maritimus* Lec.

Saprinus scissus Lec.

Saprinus bigemmeus Lec.

‡*Saprinus sulcifrons* Mann.

*This species is not recorded as being as far south as California in Leng's Catalogue of The Coleoptera.

MELYRIDAE

Endocodes basalis (Lec.)

ANTHICIDAE

Anthicus californicus Laf.

Anthicus maritimus Lec.

DERMESTIDAE

‡*Dermestes marmoratus* Say.

TENEBRIONIDAE

Eulabis obscura (Lec.)

Phaleria limbata (Horn)

CHRYSOMELIDAE

Diachus auratus (Fab.)

CURCULIONIDAE

Phycocoetes testaceus Lec.

‡The names thus checked are recorded by Lea Myers, Coleoptera From The Claremont-Laguna Region. Jour. Ent. and Zool. 1918. Vol. X. No. 3. pp. 43-53.

Some Common Chinese Mollusca

ARTHUR S. CAMPBELL

During the last year I had the opportunity to collect and examine a number of the commoner littoral and freshwater shell-bearing Mollusca occurring near Canton and at Chung Chow, Hongkong territory. The shells enumerated include only a fair sample of what might be obtained after longer search under more favorable conditions.

It is interesting to note the alliance of this fauna with that of the islands of the Pacific and with that of the California coast. A number of species occur here that are found on the opposite shore but there is a very complex admixture of the more definitely warm-water forms and with some species of endemic origin. The observations of Ralph Arnold (Palae. San Pedro, Calif., Acad. Sc. 03) concerning the tertiary shells of San Pedro and Japan shows us the affinities at once of the living shell-bearing mollusca of these two regions and likewise adds to our observations concerning the relationship between the whole Pacific molluscan complex. The molluscan fauna of South China appears to be paleotropical considered in its broadest aspect.

All shells were determined by Dr. H. A. Pilsbury of the Philadelphia Academy. In all there are one hundred and thirty-seven species represented in this collection.

(Contribution from the Zoological laboratory and Museum of the Biological Survey of South China, of Canton Christian College).

GASTROPODA

Bullidae

Bulla ampulla L.

Acmaeidae

Helcioniscus eucosmia Pils.

H. toreuma Rve.

Haliotidae

Haliotus diversicolor Rve.

Turbinidae

Turbo coronatus var. *granulatus* Gmel.

T. intercostalis Pils.

T. japonicus Rve.

Neritidae

Nerita lineata Gmel.

N. undata L.

N. crepidularia Lam.

N. albicilla L.

Solariidae

Architectonica perspectiva L.

Littorinidae

Littorina irrorata Say.

L. palliata Say.

Viviparidae

Viviparus rossgeri V. Mlldff.

V. ciliata Rve.

V. orientalis Lea.

V. chinensis Gray.

V. aeruginosus Rve.

Cerithiidae

Cerithium morus Brug.

Clava sinensis Gmel.

Melaniidae

Melania ebenina Brot.

Strombidae

Strombus pugilis var. *alatus* Gmel.

S. canarium L.

S. succinctus L.

S. bittatus L.

Turritidae

Turris desbayesii Doumet.

Cassididae

Cassis japonica Rve.

C. inflata Shaw.

C. strigata Gmel.

Doliidae

Tonnia allium (Soub.) Dillon.

Pyrula dussumieri Val.

P. ficus L.

Cypraeidae

Cypraea arabica L.

C. carneola L.

C. erronea L.

C. moneta L.

C. erosa L.

C. helvola L.

Muricidae

Murex torrefactus Sowb.

M. adustus Lam.

M. fulvescens Sby.

M. tribulus L.

Rapana bulbosa Sol.

Cymatium (*Turrotriton*) *pfeifferiana* Rve.

Gyrineum tuberculata Br.

Thaisidae

- Thais luteostoma Dillon.
- T. lapillus L.

Nyctilochidae

- Bursa rana L.
- Distortrix reticulata Link.

Columbellidae

- Columbella versicolor Sby.

Buccinidae

- Buccinum undatum L.
- Eburna lutosa Lamb.
- E. areolata Lamb.
- Alectrion obsoleta Soby.
- Buscyon perversa L.
- B. (Sycotypus) canaliculata Say.

Trochidae

- Monodonta labrio L.
- Tegula rusticum Gmel.
- T. nigerrima Gmel.
- T. argyrostoma Gmel.
- Astraea undosa Wood.

Volutidae

- Mitra aurnita Desh.

Olividae

- Olivella sayana Rav.
- O. (Callianax) biplicata Sby.
- O. scripta Lam.

Conidae

- Conus suturatus Rve.
- Conus carinalis Hw.
- Conus sulcatus Hw.

Turritellidae

- Turritella bacillum Kiener

Helicidae

- Eulota similaris Fer.
- Polygyra albolabris Say.
- Camaena cicatricosa Mull.

Cyclophoridae

- Cyclphorus elegans Mldff.

Pyramidellidae

- Pyramidula alternata Say.

Naticidae

- Natica (Polinices) mamilla L.
- N. P. melanostoma Gmel.
- N. P. didyma Bolton.
- Sinum neritoideus L.

Auriculidae

Melanpus luteus Guoy.

Scalidae

Epitonium lamellosa Lam.

Siphonaridae

Siphonaria japonica Don.

S. cornuta Gld.

S. sirius Pils.

PELECYPODA

Arcidae

Arca (*Scapharca*) *campechiensis* Gmel.

A. decussata Sby.

A. obtusa Rve.

A. granosa L.

A. (*Brabatia*) *fusca* Brug.

Parallelepipedum torta St. March.

Mytilidae

Mytilus smaragdinus Ch.

M. californicus Conrad.

M. edulis L.

Modiolus fortunei Dkr.

Septifer virgatus Wiegen.

Pinnidae

Pinna incurva Gmel.

Atrina tuberculosa Sby.

Pernidae

Malleus albus Lam.

Ostreidae

Ostrea lakerousi Lamb.

O. cristata Born.

Pectinidae

Pecten pyxidalus Boru.

P. circularis Sby.

P. circularis var. *aequisulcatus* Cpr.

P. gibbus var. *irradians* Lam.

Amusium pleuronectes L.

Spondylidae

Spondylus cruentata Lisch.

S. imperialis Chemi.

S. sinensis Sby.

Unionidae

Anodonta woodiana Lea.

Veneridae

- Tapes variegata Handley.
- T. tristis Lam.
- T. phillippinarum A and R.
- T. phenax Pils.
- Tivela stultorum Maue.
- Gafarium divaricatum Gmel.
- Venus (Chione) cancellata L.
- V. C. thiara Dillw.

Mactridae

- Mactra (Spirula) solidissima Dillw

Cardiidae

- Cardium robustum Sol.
- C. rugasum Sby.
- C. sinensis Sby.

Chamidae

- Chama rubea Rve.

Myidae

- Corbula erythrodon Lamb.

Solenidae

- Solen grandis Dkr.

Tellinidae

- Tellina alternata Say.
- Metis balaustina L.
- Paphia striata Lam.
- Caecella cumingi Desh.

Cyrenidae

- Corbicula fuscata Lam.
- C. fluminea Mull.

Ptericolidae

- Ptericola pholadiformis Lamb.

Anomiidae

- Anomia simplex D'Orb.

XIV. Echinodermata

ASTEROIDEA

The nervous system of the starfish is about the same in all forms which have been studied. Only minor unimportant differences can be recognized and some of these may be due to the different conditions under which the observations were made or the different methods employed.

Along the radial and circumoral ambulacral vessels on the oral side is a median thickening of the surface epithelium. This is the chief part of the nervous system, that is the superficial radial and circumoral system. Separated from these portions by connective substance there are in each arm on each side of the middle line the deep radial bands while within the nerve ring about the mouth there are two deep circumoral bands continuous with the two in each arm.

From the superficial nervous system fibers may be traced directly to the surface layers of the tube-feet. From the inside nerve rings, fibers follow the ambulacral system. The superficial system is merely a thickening of the epidermis in certain regions while the deep system is a thickening of the surface of the ambulacral system. Nerve strands from the circumoral rings, probably from the deep rings, run to the stomach and other viscera.

In addition to the parts of the nervous system just described there is a rather diffuse network of fibers and probably cells, found in the body-wall outside of the muscles. This last has been called the coelomic.

Sense cells and perhaps something of a nerve plexus seem to be present below the epidermis all over the aboral and lateral parts of the starfish. Just what relationship all these parts of the nervous system bear to each other or how they may be distinguished from each other, has never been made entirely clear.

Almost any portion of the body seems to be sensitive to touch and there may be other sensations without special organs for their perception. At the tip of each arm a little tentacle or papilla marks the end of the radial canal and the superficial nerve cord. This little organ has a special epithelium and may be a special organ of touch but Eimer, 1880, considers it as an organ of taste.

The eye-spot is the most marked sense organ of the starfish. Each arm has, very near the termination of the radial nerve at the tip of the arm, a bright red spot of pigment. A little closer examination of one of these spots shows it to be composed of a number of distinct regions of color. In section these little areas are seen to be little follicles lined with epithelial cells. The cells which line the follicles are spoken of as the visual cells. These are clear at their inner margins but pigmented farther down. Their inner processes come into relation with the nerve strands at the bases of

the eye-spots. Between and surrounding the visual cells are numerous bipolar, elongate supportive cells which stain strongly with connective tissue stains. In some cases the eye areas are not in the form of follicles as Pfeffer, 1901, has shown in a species of *Astropecten*. In those eye areas which appear as follicles a lens has been described and figured by Pfeffer and others but I am inclined to the interpretation of Cuenot, 1887, who believed that no lens is present. In fact, in some sections which I have seen there was no sign of even a membrane over the mouth of the follicles.

In the superficial system many long supportive cells help to make up the bulk of the nerve cord. These stain deeply with usual stains and at their inner ends are more or less intertwined.

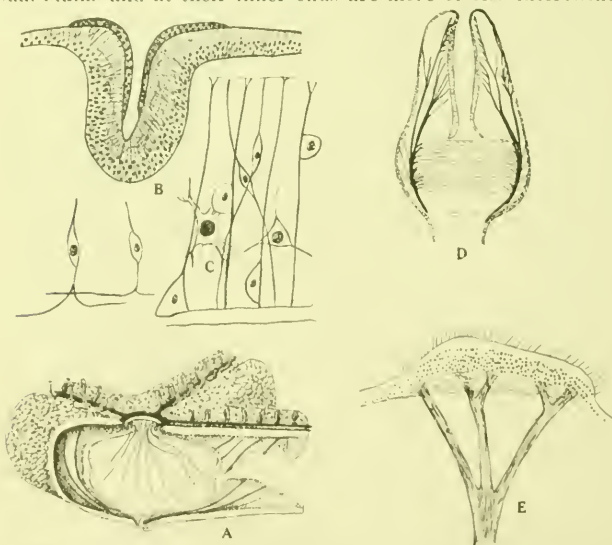


Fig. 27. A. Diagram of a Starfish cut so as to expose internal as well as external parts of the nervous system. In the center the deep nerve ring is shown by a dark curved line, the surface nerve ring by a thicker line. These parts are continued into the arm cut longitudinally on the right. Nerves to the tube-feet are shown. The superficial nerve plexus and internal nerves are indicated. B. Cross section of the radial nerve of starfish, superficial and deep parts shown. C. Nerve cells and supportive cells from the central nervous system. D. Section through one of the pedicellariae of sea-urchin showing distribution of nerves, after Hamann. E. Section through "taste knob" of sea-urchin. Hamann.

In the past I have been inclined to consider these as in part at least with conductive function, but I am sure the true nerve cells are sometimes bipolar, possibly in some cases multipolar with fibers running longitudinally and laterally in the nerve strands. The true nervous elements are more delicate, their fibers or fibrils cross each other at various angles but bear no other obvious relations to each other.

Among the earliest works on the nervous system and sense organs of starfish is that of Haeckel in 1859. In 1860, Wilson has a remarkably clear and accurate paper on the nervous system of the starfish. Another early paper was by Owsiannikow in 1871. Teuscher in 1856, figures the nervous system but not in much detail. Ludwig, 1878, has his figure of the nervous system in section often copied. Hamann, 1883-5, shows more of the structure of the nervous system and gives a good idea of the structure of the eye. Cuenot, 1887, gives a clearer idea of eye structure but not much more about the detail of the nervous system. Jickeli, 1888, recognizes four chief parts of the nervous system of starfish: (1) The ambulacral, (2) the sub-epidermal body plexus, (3) the deep nerves, (4) the intestinal nervous system. Pfeffer, 1901, studies the eyes particularly and distinguishes clearly between supporting cells and nerve cells. More recent papers of Pietschmann, 1906, and especially of Meyer, 1906, show details in the nervous system. The last author distinguishes clearly between supportive cells and nerve cells in the nervous system. He finds the supportive cells uni- or bipolar and usually running from the ventral to the dorsal side of the nerve bands. The nerve cells are bipolar or multipolar with fine branches.

Romanes, 1885, found besides strong negative reactions against injurious stimuli, positive reactions of a chemical nature which he considered due to the sense of smell. This sense depended somewhat on the physiological condition of the animal, chiefly upon its degree of hunger. A starfish, kept several days without food, immediately crawled near some presented. If a small bit of food be withdrawn as the animal approaches, the starfish could be led about in any direction. By severing various parts of the rays, Romanes found that this so-called olfactory sense was equally distributed throughout the length of the body and by varnishing the upper surface he found that the reactions were unaffected. Also by placing a bit of food on the aboral surface no reaction occurred. Preyer, 1886, found great differences in individuals when stimulated with food.

Starfish are positively phototropic but largely lose this tendency if the eye-spots are removed. Romanes found the sensitiveness so great that starfish discriminated between ordinary pine boards covering the tank and the same boards painted black. Romanes Preyer, Jennings and others have studied the righting

reactions of starfish in considerable detail. In general the starfish rights itself by twisting about two or three of its rays until the suckers on the ventral side have a firm hold of the supporting surface and by controlling the twisting movement the body is turned over. In this it is necessary that all five arms do not make the attempt at once to bring the animal into a ventral position. If five or four arms should work at once the animal could not turn over. There must be some coördination between the arms as is seen when the circum-oral nerve is cut. In this case the coöperation of the arms ceases. A single arm removed from the rest can right itself. These experiments seem to show that the central nerve ring acts merely as a conductor of impulses. The ventral side of the starfish seems to be positively stereotropic.

If one arm of a starfish is stimulated the animal moves away in a direction opposite to the stimulated arm. This looks like intelligence, but when one arm is stimulated the tube-feet on this arm draw in and according to the parallelogram of forces, a movement away from the point of stimulation will take place. When the starfish is stimulated as a whole the spines and pedicellariae wave about and the jaws snap time and again. A separate external stimulus is not necessary for each opening or closing of a pedicellaria. Mechanical stimuli that are strong enough always cause them to attack. Very light mechanical shock often produces no effect even if repeated. There are some responses to food rather than defensive movements, a nutrient juice causes the pedicellariae to advance and open. Pedicellariae are often opened for attack. If another starfish brushes against it, even when one of the individual's own rays cross, the pedicellariae may be advanced.

If closed pedicellariae are stimulated they must first be stimulated to open before they will attack. Any stimulus which causes the pedicellariae to rise will when repeated cause them to open. Most stimuli which cause the pedicellariae to withdraw also cause them to close. The larger pedicellariae are usually less inclined to hold objects for a long time. Starfish seem to hold objects for a longer time than sea urchins.

In starfish the pedicellariae seize and hold each other as well as other objects. If a small bit of the body of a starfish, bearing a single spine be cut from the rest, the pedicellariae seize any small object which touches them. If the ventral nerve is cut or the whole ventral side of the ray cut the pedicellariae continue to act, but the cutting of the nerve acts as a stimulus. The transmission of impulses seems to be by the nerve-nets over the body-wall.

Jennings has shown that the elevation of the groups of pedicellariae or the rosettes to attack, is dependent upon the following: 1. Previous mechanical stimuli; 2. Preliminary chemical stimuli; 3. Foregoing chemical stimuli; 4. Cutting the radial nerve leaves the rosettes in such a state that they attack more readily than usual. 5. The rising of the rosettes in a central region leaves them

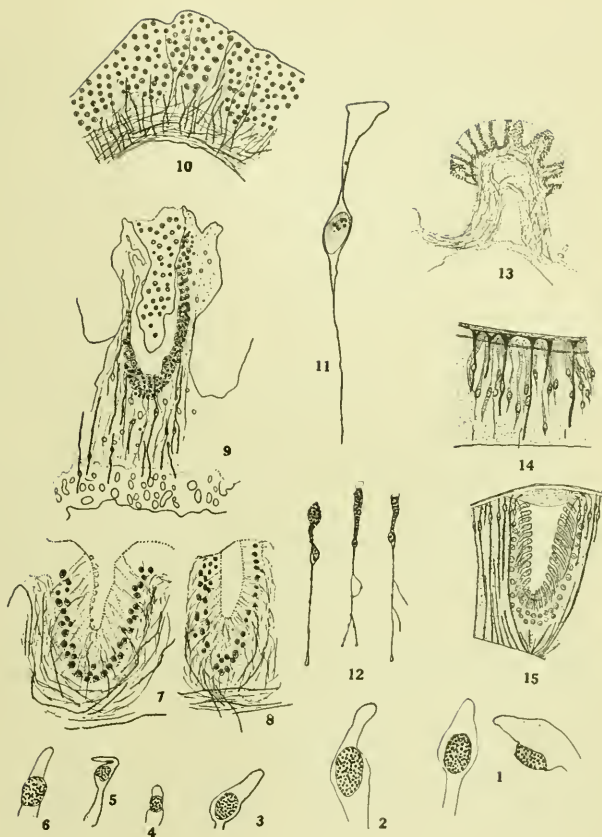


Fig. 28. SENSE ORGANS OF STARFISH. From Campbell.

1. Ventral and lateral views of eye-pad *Pisaster capitatus*, showing general relationship to terminal tentacle. X9.
2. Ventral view of eye-pad of *Orthaster gonolena*. X9.
3. Ventral view of eye pad of *Pisaster ochraceus*. X9.
4. Ventral view of eye-pad of *Asterina miniata*. X9.
5. Ventral view of eye-pad of *Linckia colombiae*. X9.
6. Ventral view of eye-pad of *Asteropectin erinaceus*. X9.
7. Ocellus from *Orthaster gonolena* to show general form. X350.
Drawn by camera lucida.

8. Ocellus from *Linekia colombiae* to show general features. X350. Camera lucida.
9. Ocellus from *Asterina miniata*. X350. Camera lucida. General view, note the clear central margin of pit.
10. Tactile organ from terminal tentacle of *Linekia colombiae*. General view showing papillae and details. Camera lucida. X350.
11. Single sensory cell from *Linekia colombiae*. Very greatly magnified.
12. Sensory cells from *Asterias rubens* showing pigment. Reproduced from Cuenot. Osmic acid. Greatly magnified.
13. General view of eye-pad of *Asteropectin erinaceus*. X350. Camera lucida.
14. Simple ocellus in an *Asterias*. Supportive cells dark. Sensory cells lighter. Reproduced from Pfeffer. Diagramatic.
15. A more complex ocellus from *Asteropectin mulleri*. Note the lens, other features as above. From Pfeffer. Diagramatic.

after subsidence in such a state that they react more readily to stimuli in a distant part of the body than the rosettes near the new stimulus; 6. There are differences in the characteristics of individuals.

The opening of the pedicellariae depends upon:

1. Homogeneous preparatory stimuli
 - (a) Sometimes there is no response to the first stimulus.
 - (b) Sometimes the first stimulus causes retraction and closing while later ones cause extension and opening.
 - (c) Sometimes with large pedicellariae the first stimulus causes momentary opening, the next two or three have no visible effect, the next pronounced opening.
2. Chemical stimuli of a certain character cause the pedicellariae to open later and more readily under mechanical stimuli.
3. Chemical stimuli of a certain character cause later refusal to open under usual mechanical stimulation.
4. Holding some object causes the pedicellariae after release to refuse to open under other stimuli.
5. After closing the pedicellariae often open and close again spontaneously. "snapping." The foregoing action furnishes the condition for the succeeding one.

In many cases the tube-feet are compelled to do much feeling about before they find the object seized by the pedicellariae. In exploring movements two or three rays are raised from the others and swung about in the water; the other rays creep about. The tip of the arm as well as the other parts of the arm are employed in these feeling motions.

The relative intensity of illumination on different parts of the body of the starfish may and at times does determine the direction of movement without regard to the direction of the rays of light. The ventral portion of the surface of the starfish is protected by

movements more than the tips of the arms. After it has been at rest for a time however the eye-spots are usually so placed as to be protected from the light. The starfish in each case (Jennings) moves towards that part of the body that is least illuminated.

There are a number of ways in which starfish right themselves according to Jennings:

1. The simplest method. Two adjacent arms twist their tips with ventral faces inwards.

2. Two arms, the ventral faces not inwards but facing in the same direction.

3. Three adjacent rays attack and usually turn by twisting the outward rays.

4. Four rays take hold, two to right, two to left. Fifth ray helped up, and swings over.

5. All rays attack release later of certain rays.

6. One ray twists and rights the whole.

7. Righting without attaching tube feet of any of the rays. Raises disc strands on tips of arms then topples over.

If a starfish begins a reaction in a certain way it usually continues in the same way even in spite of opposing conditions. When the starfish gets started it continues in the same way. The variability of form in starfish that are righting themselves is very great. No species rights itself in one way alone. When certain tube-feet are prevented from acting in righting movements the others carry on the movements. In righting if one method does not help another is used.

HABIT FORMATION

Preyer, 1886, Jennings, 1907, have brought further information as the results of experiments to test habit formations in starfish. By preventing certain rays to act in the righting reactions in starfish Jennings showed that he could establish temporary habits and the slower formation of more lasting habits. The many factors which determine the righting reactions have not a constant tendency to make starfish turn on one given pair of rays. On the contrary, they must sometimes act in one way, sometimes in another. Therefore no very fixed habits are formed under normal conditions.

In the righting reactions the impulse tends towards the accomplishment of the general turning of the starfish as a whole and given parts sacrifice their own direction or even prevent it in the general result.

We cannot assume single specific external stimuli as the determining factors for each separate movement, yet in some way the relation of the organism to its environment has set in operation a uniform action of which separate movements are parts.

ECHINOIDEA

The nervous system of sea-urchins may be compared with that of starfish more easily than with that of other forms.

The nerves corresponding to the superficial radial and circum-oral nerves are more deeply placed than in starfish and as in starfish are the most obvious parts of the nervous system. An epineural space or tube on the outer side of the nervous band forms the so-called "epineural cavity" or nerve tube, as interpreted by Phouho, '87, and others. The radial and circum-oral sinus follows the nervous system on the inside.

The superficial radial system follows down the inside of the shell in the center of the ambulacral area and these five strands join with the circum-oral ring about the mouth opening.

From the nerve ring between the junctions of the five radial nerves are branches to the intestine which go to make up the intestinal plexus. Nerves run out laterally from the radial nerves to the tube-feet and also to the surface, to the bases of the spines and to the ganglia at the bases of the spines. The radial nerves end in the terminal tentacles through holes in the shell about the anal region. It is by way of these openings, according to Phouho, that the radial nerves contribute to the superficial nerve plexus just outside the test of the sea-urchin. The deep radial nervous system is but poorly represented, so little of it is present closely applied to the superficial radial and circum-oral that it can hardly be recognized apart from it.

According to some, a pentagonal area of aboral nerves surrounds the anus and communicates with the genital organs and with the external superficial system by means of fine fibers from the radial nerves near their termination in the terminal tentacle. It is quite probable that the superficial system communicates with that of the shell at the aboral end not only through the so-called ocular openings but also through the genital openings in the shell.

The surface of the body, the spines and the tube-feet, are all organs of the tactile sense at least.

The so-called eye-spots at the terminal tentacle in the five ocular plates contains pigment and may have some sensitiveness to light, but it is not like the eye-spots of starfish and may indeed not be in any sense an eye-spot.

The chief parts of the system such as the radial and circum-oral nerve bands are composed of about the same parts as in the starfish. In smaller and perhaps younger specimens the outer nuclear layer is thicker in proportion. Nerve cells are bi- and multipolar. In some cases at least multipolar cells are found well within the fibrous area of the strand. Many of the outer cells are probably as in other echinoideans supportive in function. The radial bands are thicker at the oral region and become somewhat

smaller at the region of the terminal tentacle in the ocular plate. This might suggest something as to the nerve tracts or bundles of fibers and gives an indication at least that fibers may convey impulses at different distances such as in the central nervous system of vertebrates.

The deep radial and circum-oral strands of sea-urchins are poorly shown in section. Only a few cells scattered along the inner margin of the fibrous region give an indication of this poorly developed system.

In the sand-dollar, *Dendraster excentricus* some variation in form is suggestive of value in comparison with other forms.

The righting reactions in sea-urchins are carried out with greater difficulty than in starfish and only the fresher or more vigorous individuals are capable of the reaction.

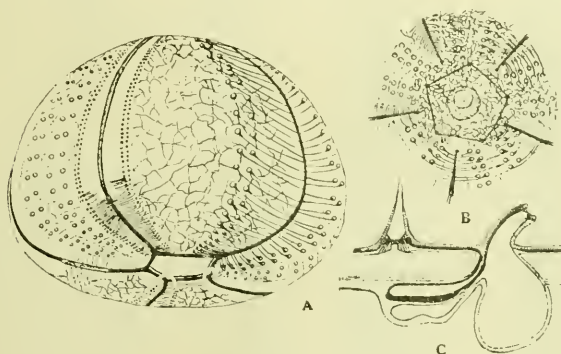


Fig. 29. NERVOUS SYSTEM OF SEA-URCHIN. A. Diagram of nervous system of sea-urchin showing in various ways the superficial and deep nervous system by having the superficial system cut away on part of the two radial nerves at the left. Branches to the tube-feet shown in the central of the three ambulacral areas. Nerves to the bases of the spines show on the right. Superficial nerve plexus show in the center. B. Diagram of the nervous system from the aboral pole, showing the nerve connections at the genital openings and the ends of the radial nerves at the five ocular plates. C. Diagram of cross section of nervous system having branches to a spine and a tube-foot after Delage and Herouard.

Although the eye-spots of sea-urchins are not well developed they seem to avoid light and seek darker corners and sheltered places. One form which has no eye-spots seems to avoid the light. A sudden shadow falling on it causes it to direct its spine to the

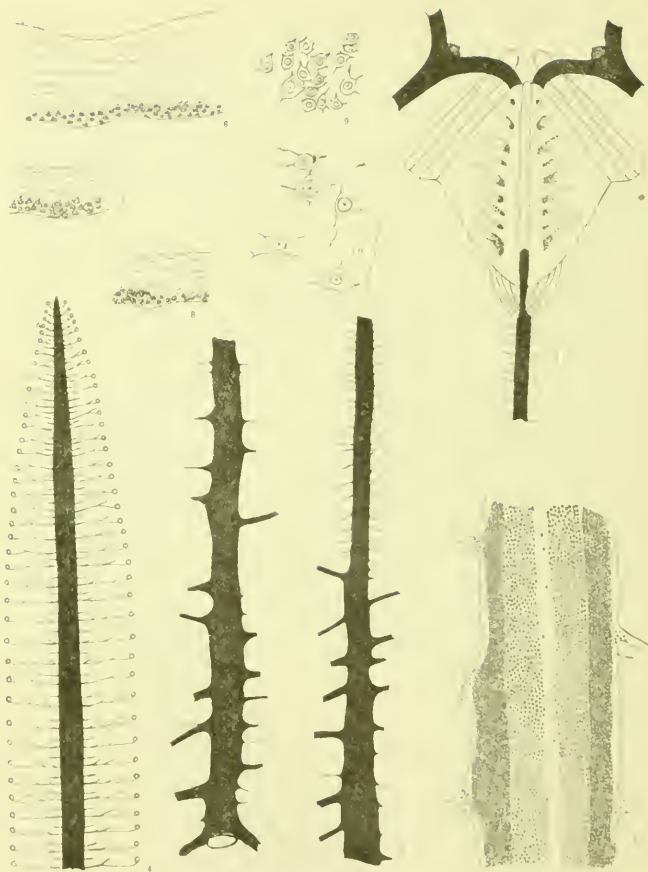


Fig. 30. EXPLANATION OF FIGURES OF SAND-DOLLAR.

1. Diagram of one fifth of Aristotle's lantern of *Dendraster* showing three loops of the circumoral nerve ring, and parts of three radial nerves, the central one partly hidden at its origin by the lantern. The nerves are in black. X9.
2. Drawing of part of the first part of an oral radial nerve, X9.
3. Drawing of the lower end of an oral radial nerve, X9.

4. Drawing of the upper part of an aboral radial nerve. The eye-spot region is up in the figure. X9.
5. Camera lucida drawing of a part of an aboral nerve showing position of cell areas. X70.
6. Drawing of a section of an oral radial nerve. X300.
7. Drawing of a section of circumoral nerve. X300.
8. Drawing of a section of aboral nerve. X300.
9. Nerve cells from central regions of a radial nerve. The arrangement is as shown in the drawing, cells of various levels shown as one layer. Some of the processes possibly relate nearby cells, but most fibers run into the general fibrous mass. All fibres or fibrils are small. There is some indication of tigroid substance in some of the cells. X450.
10. Nerve cells from near a lateral branch from the radial band. X450.

shaded area. Uexkull, 1897, was of the opinion that the sea-urchin possessed a special set of nerve fibers concerned with photic responses.

If a bit of the test with one or more spines be separated from the rest of the animal, the spine or spines may be stimulated to react much as before. In the sea-urchins there are several kinds of motile organs. There are the jaw-like organs or pedicellariae, borne on movable stalks; there are the tube-feet and the long movable spines. All these sets of organs are controlled by nerves, and a nerve network connects all these motile organs. One general network of nerves is within the shell and one without, and these are connected with the five radial nerves and the circumoral nerve ring. Each of these motile organs has a definite number of reaction or responses and in these each group may act independently and each organ may react as an independent individual. Each sea-urchin then seems according to Uexkull to be made up of a colony of almost independent structures yet all these are connected by the nerve network and when one carries out a reaction others may receive a stimulus to carry out its special activity.

The independence of these systems of spines, pedicellariae and tube-feet, and the definite character of their reflexes has been clearly expressed by Von Uexkull. He considers the sea-urchins as made up of a "republic of reflexes." Each reflex is of the same value and is independent of the others except for the nerve-net connections between the systems. This group of chiefly independent systems has nothing like a central unity controlling them as a whole and it is only by the synchronous course of different reflexes that a unified action is simulated. The action is not unified but the movements are ordered. Separate reflexes are so constituted and so combined that the simultaneous but independent course of reflexes in response to outer stimulus produces a definite general action similar to the condition in animals with a common center.

The pedicellariae of sea-urchins refuse to seize or hold each other or parts of the bodies or others of the same species. Von Uexkull believes this is due to a presence of a substance "auto-dermin" which is in the skin. In sea-urchin pericellariae have the power of independent reactions. Each when isolated on a piece of shell may behave as when on the body of the animal. The stimulus from the pedicellariae need not pass through the radial nerves for if the nerve is cut the reactions are as before.

OPHIUROIDEA

The nervous system of serpent-stars is more complicated than that of starfish. The radial and circum-oral nerves are shut off from the surface of the body and inclosed in a small cavity. The more superficial radial and circum-oral nerves are well developed and from the radial nerves fibers run out to the spines of the legs and the tube-feet. These last are provided with ganglia at their bases and with nerve strands running their length. The nerves which run to the spines also have ganglionic thickenings upon them at the bases of the spines. From the ganglia at the bases of the tube-feet delicate strands run out to one epineural ganglion for each tube-foot. On the ventral side of the disc on each side of radial nerves lateral nerves run out to near the margin of the disc communicating with the radial nerves and also connected with the superficial nerve plexus on the lower side of the disc. There are then in this way two lateral nerves from each arm base, and each one of these sends out an inter-radial nerve. Nerves from the circum-oral ring run to the teeth, five pairs in all.

The deeper radial and circum-oral nerves are closely applied to the more superficial nerves and appear much like parts of them, being represented by groups of dorsally placed cells. These deeper nerves are two for each arm. The circum-oral ring about the mouth sends out pairs of nerves to the muscles of the arm.

A system of so-called genital nerves is found quite distinct and independent from the other systems. More or less isolated loops of fibers are found in each area of the disc between the arms.

Hamann, 1888, gives one of the best accounts of the nervous system. Delage and Herouard also figure and describe the nervous system in this group. The first author describes and figures nerves coming out laterally from the chief radial nerve to be applied to the skin. These may be the cutaneous nerves of Delage and Herouard.

Hamann also shows strands from these to the tube-feet where ganglia are located and from these ganglia are nerves with ganglia running in to the center of the arm, and also nerves arching up dorsally to end in small ganglia. These are very much in the position as shown in the diagrams and figures.

The chief radial nerves, as is well known, are concentrated into ganglion-like swellings at the intervals between the vertebrae and here from the dorsal nerve cord strands are sent into the muscles of the arms.

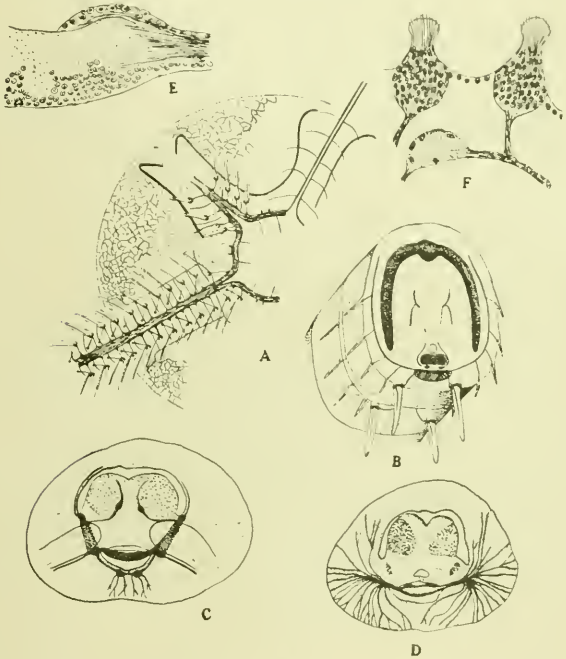


Fig. 31. NERVOUS SYSTEM OF SERPENT-STARS. A. Diagram of the nervous system of a serpent-star, a part of the disc and the bases of three rays shown. In the upper right end ray the superficial nerve ring and radial nerve are removed to show the deeper nerves. In the others and on the disc other nerves are shown. On the disc the superficial nerve-net is given. Out from the radial and circum-oral nerve the chief branches to the tube feet, etc., are shown. B. Diagram of the nervous system of one of the arms cut across showing large cavity of an arm in deep shading and the lowest cavity within radial nerve, with branches to spines and tube-feet. C. Diagram of section of an arm after Hamann. D. Through the arm at another level. E. Section through radial nerve. Hamann. F. Section through sense papilla. Hamann.

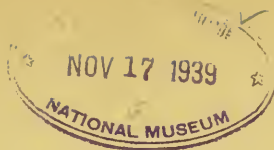
The parts of the nervous system are:

1. The superficial radial nerves. The chief branches: (a) muscular nerves, (b) cutaneous nerves to tube-feet and to skin and to spines. On each nerve to the tube-feet a ganglion is formed at base of each tube-foot and strands run dorsally and centrally to the intervertebral ganglia and ventrally to the two ventral ganglia or epineural ganglia. (c) branches communicating with the lateral nerves of the disc on each side of each radial nerve which in turn have altogether 10 interrarial nerves near the center of the disc and branches to the superficial nerve plexus.
2. The superficial oral nerve is pentagonal in shape and gives off: (a) nerves to the stomach, (b) a pair of dental nerves.
3. The deep radial nerves give off nerves to the muscles of the arms.
4. The deep oral ring gives off: (a) interrarial superior nerves, (b) interrarial internal nerves.
5. The genital nerves, independent of the others. Five different nerves between each radial area in the disc.

There are no eyes. The skin has no cuticle except at certain points and these are the only ones where sense cells are located. The tube-feet and spines are sensitive to touch. The palps are sensitive to touch as well as parts of the general surface. The extremity of the palps have sensory functions. The terminal tentacle, it is thought, may be olfactory in function. The oral palps have sensitive papillae well supplied with nerve cells.

The structure of the nervous system is somewhat like starfish but the central cords are parallel with more evident nerve cells and the strands seem to have a more complicated structure.

Hamann's work is perhaps the most valuable in this group. Delage and Herouard make chief use of this in their work. Teuscher 1876, Land, '76, Smith, '79, and Ludwig, '80, are the other chief contributors who have considered the nervous system.



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A New Salt Marsh Mealy Bug

(*Eriococcus palustris* n.sp.)

CLIFFORD T. DODDS. University of California

Introduction.—While making a study of the insects of the salt marshes and brackish waters of the San Francisco Bay region, I chanced to find in considerable numbers, a mealy-bug on the salt-marsh cord-grass (*Spartina foliosa* Trin.). It occurred on the upper surface of the leaves and generally out of reach of the ordinary high tides. The probable reason why this mealy-bug, as well as the scale, *Chinaspis spartinae* Comst., occurs almost entirely on the upper surface of the leaves is because of the fact that during transpiration, water is given off from the lower surface of the leaf, leaving after evaporation a considerable deposit of salt.

Type host and locality.—From *Spartina foliosa* Trin., at Almonte, Marin Co., California, November, 1921. Found wherever the host is located about the shore of Richardson's Bay, an arm of San Francisco Bay.



Fig. B. Leaf of host plant *Spartina foliosa* Trin.; w, *Chinaspis spartinae* Comst., adult female; x, *E. palustris*, female before secreting sac; y, sac that has been wet by the tide; z, normal sac.

Sac.—The natural sac is composed of fluffy white waxy filaments (Fig. B, z), which after they have become wet by the tide, and this is usually the case in nature, become a light ashy gray (1), and have a more or less feltlike texture (Fig. B, y), thus offering great protection, especially for the overwintering young. At the posterior end of the sac there is an obscure opening, plugged with wax filaments, where the young escape. The average length of the sac is 4 mm. for the adult females and somewhat less for the males.

Adult female.—*type*—(Fig. A) Body smooth; six cephalothoracic spines on the dorsum, the two median anterior ones being larger than the other four, all straight, slightly expanded at the base, tapering to a rather blunt apex; eight pairs of very small, blunt, conical, dorso-lateral marginal spines on each side; the

posterior spine of the last pair of each marginal series slightly larger than the others. On the ventral surface there are sparsely scattered hairs, arranged segmentally; four spiracles located posterior to the coxae of the front and middle legs. Anal lobes not chitinized, each with three small ventral and one large terminal setae (Figs. C, D) and two dorso-lateral spines on the inner surface. These spines are slightly larger than the cephalothoracic spines mentioned above, not expanded at the base and very blunt. The last pair of the marginal spines are located dorso-laterally near the basal end of the anal lobe (Fig. E). The terminal setae of the anal lobes are about two and one half times as long as the anal lobes themselves (Fig. C), while the eight setae of the anal ring are less than the length of the anal lobes. Antennae medium stout, six to eight segmented (Figs. G, H, I, J), the normal long

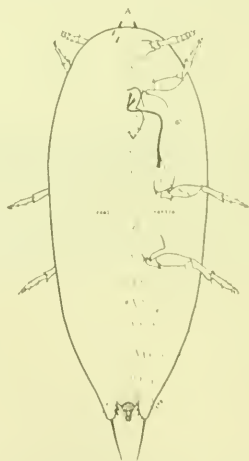


Fig. A. *Eriococcus palustris* n. sp., adult female cleared in caustic potash.

third divided into the third and fourth, and the normal ultimate segment divided into the seventh and eighth. Apparently this division is not closely related to the moults. Legs rather slender (Fig. F), claws not toothed, digitules with flat apical enlargements.

Male.—Body 1 mm. long; folded wings projecting $\frac{3}{4}$ mm. beyond end of abdomen.

Eggs.—Average 60 to 70 eggs per female, 92 highest number noted. Ellipsoidal, pale cadmium yellow (1) ; .5 mm. long, .25 mm. wide.

Type and paratypes deposited in the California Academy of Sciences, paratypes also deposited as follows: United States National Museum, Washington, D. C.; G. F. Ferris, Stanford University, Palo Alto, California; E. O. Essig, University of California, Berkeley, California, and in my own collection.

Comparison.—This is a very distinctive species, the small number of spines, their form, size and distribution separating it quite widely from the known species of this state. The only species that I have seen which at all resembles it is *Eriococcus inermis* Gr., which is found on grass at Camberley, Surrey, England.

Life history.—As a rule the females come to rest with the cephalic end of the body uppermost on the erect leaves, where they

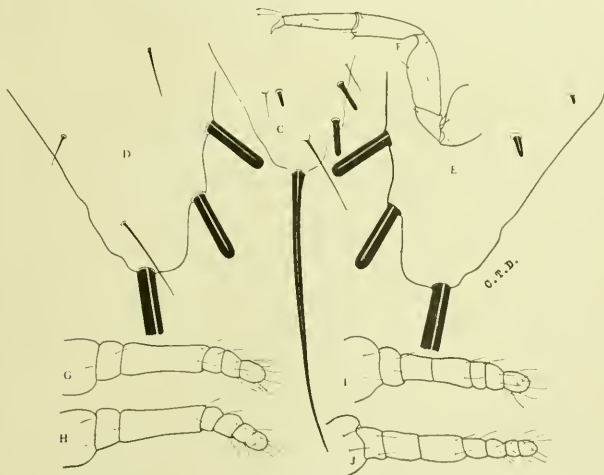


Fig. C. Anal lobe showing relative positions of dorsa-lateral spines to ventral setae.

Fig. D. Ventral aspect of anal lobe.

Fig. E. Dorsal aspect of anal lobe.

Fig. F. Leg.

Figs. G, H, I, J, showing variation of antennae.

Note: (1) Nomenclature of Windsor and Newton's water colors as given in the "Glossary of Entomology", Smith. Brooklyn Ent. Soc., Brooklyn, N. Y., 1906.

secrete the sac about themselves. The eggs are layed in the bottom of the sac, being quite closely packed with wax filaments. As the female deposits the eggs her body is crowded forward, the dead remains being found in the upper end of the sac. In some instances in the laboratory, it was noted that undersized females would secrete a sac, deposit a small number of eggs and die. Upon dissection, it was found that there were often mature eggs in the oviducts or partly developed eggs in the ovaries. The first laid eggs in the bottom of the sac hatched several days in advance of the others and thus the nymphs escaped before the later eggs hatched.

Under laboratory conditions the first moult took place 17 days after hatching and the second moult a week later. After the second moult the individuals had lost the pale cadium yellow color and became the violet gray of the adult. The day following the second moult they secreted sacs, although they were very much smaller than those which first made sacs under natural conditions. Normally they probably have five moults. The overwintering individuals found in nature were first instar nymphs which had not left the sac.

Parasites.—One Hymenopterous insect was found, *Pseudococcobius claussemi* Timberlake (2) which parasitized a large percentage of the mealy-bugs. As many as six of these parasites were found in an adult female. They usually kill the female after she has made the sac and before oviposition. They overwinter in the sac as adults, emerging in the spring through circular holes which they make.

Resistance to drowning.—Several experiments were made to see if this insect was specially protected from the water. It was found that submergence for three or four days had no ill effect on an adult and that they could float on the surface of fresh water for three weeks without dying. These results are of little significance, however, as Mr. Floyd Wymore, in his B. S. thesis work at the University of California, 1922, found that *Pseudococcus gahani* Green, a terrestrial mealy-bug, not only could live under water but laid eggs and otherwise lead quite a normal life.

Acknowledgements.—I am deeply indebted to Prof. G. F. Ferris of Stanford University for numerous courtesies, especially for determining this mealy-bug as a new species and for the permission to examine his collection of Coccidae. I am also indebted to Mr. W. C. Matthews for photographing figure B, and to Prof. E. O. Essig for suggestions and aid.

Note: (2) Mr. A. B. Gahan, Entomological Assistant of the United States National Museum, writes as follows: "The parasite appears to be *Pseudococcobius claussemi* Timberlake. This species was described from a single male specimen bred from *Erium* sp. [*Lichtensioides* Ckle.] * * * at Riverside, Calif. Your males differ very slightly in the extent of yellowish color on the face but I believe there is very little reason to doubt that they represent this species with the type of which they have been compared."

Notes on the Life History of *Dinapate wrightii* Horn. (Col.)*

By ROY E. CAMPBELL, U. S. Bureau of Entomology, Alhambra, Cal.

In May, 1916, Mr. J. O. Martin, of Pasadena, after considerable tedious scouting, discovered a log of the Washington Palm (*Washingtonia filifera*) in Palm Canyon, on the Northwestern border of the Colorado Desert, which contained partially-grown larvae of *Dinapate wrightii*. Mr. Martin could hear more larvae at work in the log, and decided to mark it and wait until the following spring for further action. In 1917 he returned to Palm Canyon and sawed out several pieces from the fallen log, carried them down the canyon to his automobile (a feat which was discovered a little later by the writer to be quite laborious) and transported them to Pasadena.¹

At the suggestion of Dr. F. H. Chittenden, the writer got into communication with Mr. Martin and received directions to locate the remaining 10 feet of the infested log. On May 19, 1917, the writer went to Palm Springs and duplicated Mr. Martin's actions, except that the scouting was unnecessary. The logs were placed in a wire cage, in Alhambra, and closely watched. Mr. Martin's efforts were rewarded by the appearance of the first beetle on August 3, and emergences continued until thirty-one had appeared by September 17. In the writer's cage 3 adults appeared in the latter part of July, and 2 in August.

When the sections were sawed from the log, a few larvae were disclosed, some practically full-grown, while others were quite apparently immature, indicating the possibility of two broods. Also after the emergence of the beetles in 1917, larvae could still be heard at work within the log.

On April 15, 1918, one piece of the log which had been transported to Alhambra, was cut up and examined. Nine larvae were found, four of which were full-grown, and the rest not over half-grown. These larvae were sent to Dr. Chittenden. Also one dead adult female, which had failed to make its way out of the log, was uncovered. The emergences of adults for that year from the remaining piece of log were as follows:

¹ Bull. Brooklyn Ent. Soc. Vol. XII No. 5, pp. 107-110, December, 1917.

*Since this paper was presented for publication, an article by Dr. J. A. Comstock on "A Giant Palm-Boring Beetle" appeared in the March, 1922, Bulletin of the Southern California Academia of Sciences (Vol. XXI, Part I). Besides giving many of his observations, it reviews the literature on this interesting beetle.

August 1, 1918—1 male.

August 2, 1918—1 male.

August 2, 1918—1 male.

August 8, 1918—1 male.

Sept. 2, 1918—1 female, elytra deformed.

Since there evidently was still another brood, or some larvae were slower in developing, the remainder of the log was kept, and three beetles emerged in 1919 as follows:

July 24, 1919—1 male, large fine specimen.

July 25, 1919—1 male, small specimen.

Aug. 25, 1919—1 female, average specimen.

No further attention was paid to the log until April 1, 1920, when out of mere curiosity, it was cut up. To the writer's great surprise one live larva was found.

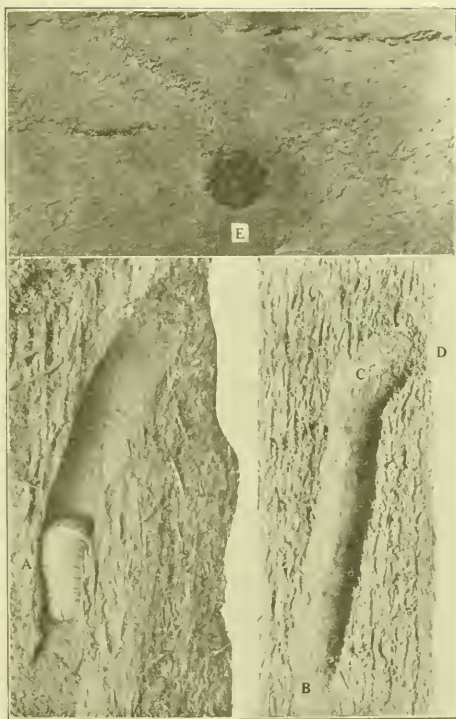
It did not appear to be quite full-grown, or at least was a little undersized, and was soft and flabby. Although it was not expected that it could mature, a hole was bored in the end of a piece of the log, near and parallel to the surface, the larva put in, the hole corked up and the piece of wood placed upside down. The larva soon began to bore into the wood.

On May 24 it was examined again. The larva had continued boring into the wood, parallel with the bark, filling up the hole behind it, and had turned around in the hole and was headed upward. It finally worked a little to one side, and started upward parallel with the other gallery. It was then transferred to another piece of log, and put in a hole bored about 2 inches deep. During the transfer, the photograph of the larva in the gallery shown in Plate I, A, was taken.

The cork plug was removed frequently and the progress noted. Not much eating was done after the above date, and on July 12 the writer was delighted to find that the pupa had formed. It was creamy white, with dark eyes. By August 4 the legs, mouth-parts and head were turning brown, and on August 8 the adult formed. It was put back in the hole and the latter plugged up. The beetle proceeded to the top of the gallery and ate its way upward and outward. It emerged from the log on August 23, a medium-sized female. The gallery eaten by the larva between the time it was put in on May 24, and pupation on July 12, in which pupation took place, is shown in Plate I, B—C, and the exit hole eaten by the beetle at C—D. The walls of the gallery made by the larva are much smoother than those made by the beetle as the latter ate its way out. An exterior view of the exit hole is shown in Plate I, F.

A resume of the above indicates the following:

May, 1916, Palm log with immature larvae discovered in Palm Canyon by Mr. Martin.



EXPLANATION OF PLATE I

A. Mature larva of *Dinapate wrightii* in gallery just preparatory to pupation. B—C. Parallel section of gallery eaten by larva between May 24 and July 12, in which pupation took place. C—D. Hole eaten by adult in order to escape from log. E. External view of exit hole.

May, 1917, Log removed to Alhambra, California.

July and August, 1917, 5 adults emerged from log.

April, 1918, 4 full-grown and 5 partly-grown larvae observed in one piece of log.

August and September, 1918, 4 adults emerged from remainder of log.

July and August, 1919, 3 adults emerged.

April 1, 1920, one nearly full-grown larva found in log.

July 12, 1920, larva pupated.

August 8, 1920, adult formed.

August 23, 1920, adult emerged from log.

The partly-grown larvae observed by Mr. Martin in 1916 must have been the ones to emerge in 1917 and 1918, indicating the life cycle to be at least 2 or 3 years. However, they may have been more than one year old in 1916. Mr. Martin believes that the small larvae observed in 1917 were from a brood deposited after the log was discovered in May, 1916. However, it is apparent that there was no deposition after the logs were taken in May, 1917, and it seems probable that the latest deposition possible was from beetles which emerged in the summer of 1916. If this is true, then the life cycle of the beetle emerging in 1920 was practically 4 years. It is possible that deposition occurred prior to 1916, which would make the life cycle 5 years or more. Beetles emerging in the other years must have been from 1 to 3 years old at the time the log was discovered. If this is so, it would make 4 separate broods, which seems improbable. It is the writer's opinion that there probably were two broods, and that the life cycle of *Dinapate wrightii* may vary from 3 to 5 years. It is certain that the period can be four years. The quantity and quality of food accessible to each individual larva no doubt had much to do with the rate of development, but probably other factors enter in also. If the log contained only one brood, then the variation in the length of life would be still greater.

It is interesting to note that when Mr. H. G. Hubbard visited Palm Canyon in February, 1897, he observed that "all larvae were thoroughly dormant and very flaccid. There are no young, and evidently all are of the same age and nearly or quite adult. I feel sure that they are more than one year old, and probably more than 2 years old, but no doubt they would have issued in July or August of this year."²

Specimens sent to Washington by Mr. Hubbard did emerge in August. His belief that the life cycle would be at least 3 years is demonstrated by the writer's experience.

² Ent. News, Vol. X, No. 4, pp. 228-230, 1899.

Mr. Richard T. Garnett visited Palm Canyon on May 21 and 22, 1917, and after extended search, found an infested log, from which he took 133 adults, 28 pupae and 17 larvae. One fresh exit hole was observed. This and other observations indicate that the period of emergence of the beetles extends from the latter part of May to the early part of September, and it is probable that oviposition also takes place during this period, perhaps continuing a little later. Mr. Garnett observed two sizes of larvae in the log.²

Only one pupal record was obtained, but judging from this, and the condition of the insects on the various dates the log was cut into or examined, it seems that the pupal period is about one month, and the adult may remain in the log two weeks from the time it forms until it eats its way out. Plate I, C—D, shows that the beetle had to bore nearly an inch from the end of the gallery in which pupation took place to the outside of the log.

In view of the relatively large numbers of such a rare beetle collected by Mr. Garnett, Mr. Martin and the writer, Hubbard's fears that the insect was about to become extinct are quite unfounded. The two infested logs were found in the same canyon but more than a mile apart.

² Ent. News, Vol. XXIX, pp. 41-44, Feb. 1918.

HOLOTHUROIDEA

In sea-cucumbers the chief parts of the nervous system are much as in other groups but the superficial and deep radial and circum-oral systems are quite distinct from each other.

The more superficial system is composed of five strands in an epineural cavity under the longitudinal radial muscles but well in from the surface of the body. The oral ring circles the peristome; at the base of the tentacles between its radial branches there are strands, one for each tentacle; other branches go to the pharynx and intestinal tract. The epineural cavity seems not present in some forms, possibly due to contraction of the animal. The radial nerves end at the anal end of the body but there is no special terminal tentacle. The radial nerves give off branches to the tube-feet and also to the skin; two nerve plexuses have been recognized, a superficial just under the epithelium and a deeper one in the body-wall. Both of these networks receive some branches from the radial nerve.

The deeper nerve ring or hyponeural divides into two strands on the inside of each superficial radial nerve according to Herouard, '87. This deeper system is chiefly motor while the superficial system is sensory, a generalization which he extends to other echinoderms. Branches from the deep system are said to supply muscles of the body-wall and lantern region.

Among the earlier works dealing with the nervous system of holothurians was that of Krohn, 1841, where the radial nerves were noticed but little detail given. Semon, 1883, and especially Hamann, show the general form and histological structure of the nervous system. Herouard, '87-'89, brings out some points, especially emphasizing the motor and sensory divisions of the nervous system, as already noted.

Gerould, '96, shows the nervous system in *Caudina* but little is said about it. Clark in *Synapta*. 1898, shows the nervous system in section. Red spots at the bases of the tentacles, the so-called eyes, are figured.

Five radial nerves are recognized and smaller branches to the tentacles. Each radial nerve is divided longitudinally into an outer and inner band as in other forms, but unlike others has no vessel of any kind accompanying the nerves and no spaces or lacunae. Each tentacle nerve sends off branches to the digits so that almost the whole surface of the tentacle becomes sensory. On the bases of the tentacles and in the ectoderm over the body are sense buds or tactile papillae such as described by Hamann, '83. Under each of these is a small ganglion. From the lower side of the circum-oral ring, between every two tentacles, a broad nerve

runs to the ectoderm of the oral disc and to the muscles of the oesophagus.

Ackerman, 1902, gives figures of the nervous system in *Cucumaria*. Retzius, 1906, by means of the silver method gives a mosaic picture of the epidermal cells. Between these cells are small oval fields, the sense cells between the polygonal areas or supportive cells. These are partly between two cells, partly between several supporting cells; they are not regularly arranged. Reimers, 1912, discusses the development of *Synapta* and gives something of the nervous system. Haanen, 1914, in *Mesothuria*, is not inclined to accept Herouard's (1890) suggestion that the inner nerve band is chiefly a motor nerve. Very fine intestinal nerves from the circum-oral nerve ring are found in this form as well as the thicker nerves found by other observers. Every tentacle and every foot has its own nerve, the first from the circum-oral nerve ring, the second from the radial nerves. The foot nerves are .029 inches broad and smaller and more circular in outline than the tentacle nerves. There seem to be at least some

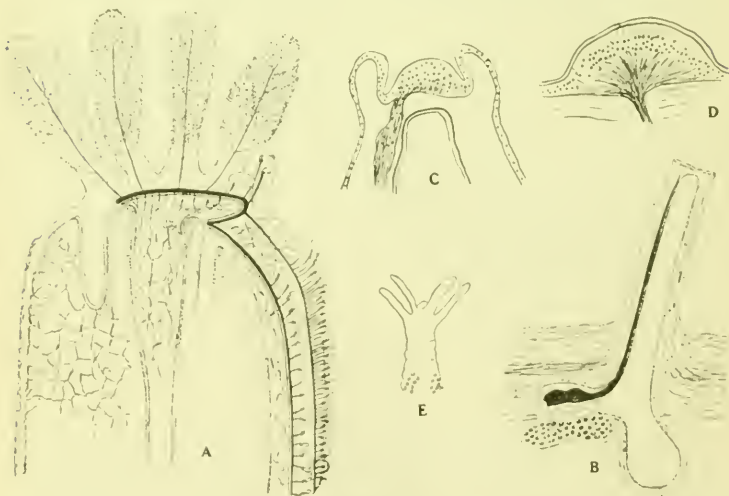


Fig. 32. NERVOUS SYSTEM OF HOLOTHUROIDEA. A. Diagram of a sea-cucumber showing superficial and deep central systems, branches to tentacles and tube-feet and the inner and outer nerve plexus. B. Section through body-wall of Holothuria showing central band in dark with nerve to a tube-foot. C. Nerve supply to tube-foot. Hamann. D. Sense papilla of Synapta supplied by a nerve. Hamann. E. Oral end of Synapta showing location of sense pores.

motor and probably some sensory fibers in these. Sense cells and an epithelial plexus were not clearly seen in this form. Retzius found sense cells in the skin chiefly about the mouth opening, in the tentacles and the tube feet. In this form the peripheral nerve fibers were not found. Crozier, 1915, discusses the sensory reactions of *Holothuria surinamensis* Ludwig.

The nervous system does not have to be intact for the act of autotomy but it is more successfully carried out when it is uninjured.

The animals are reactive to tactile, vibratile, photic, and chemical stimuli, and practically indifferent to heat in the way of a sensation.

The parts of the body are sensitive in the following order, beginning with the most sensitive: (1) tentacles, (2) anterior end, (3) posterior end, (4) papillae, (5) pedicels (Podia), (6) mid-body surface.

The tube-feet discs are positively stereotropic. This shows in the righting reaction. The arms are photokinetic, negatively phototropic; they do not respond to increase in light intensity, but respond negatively to decrease in light intensity. The whole surface is sensitive in this way. The fluorescent skin pigment is possibly concerned.

Dissolved substances representing those homologous to human taste qualities for sour, bitter sweet, salt and alkaline, are effective as stimuli.

CRINOIDEA

There are three distinct parts of the nervous system:

1. The superficial epidermal.
2. The deep oral system, according to the suggestions of Delage and Herouard.
3. The deep aboral system.

The superficial oral system is much like the radial and circum-oral system of starfish, with the nerve ring and radial nerves running down the surfaces of the ambulacral grooves in each arm with branches to the surface and to the little elevations covered with sense hairs.

The deep oral system according to Delage and Herouard's interpretation is in the connective tissue under the epidermis and consists of a central nerve ring and strands down each arm with branches to the pinnacles.

The deep aboral system develops later than the oral in the young form. It is in the center of the so-called chambered organ. There is a central mass of nervous matter in the chamber; strands run out from this towards the arms and fork but are united again.

to form a ring or pentagon of nervous tissue. From this ring strands run out to each arm and branch and are distributed to the arms, running embedded in the ossicles of the arms.

Carpenter, '66, and Marshall, '84, found that the aboral nervous system controls the movements of the animals. If the chambered organ is destroyed the animal is paralyzed, but it will swim readily or make the necessary movements just as well when the whole ambulacral nerve ring and alimentary canal are removed.

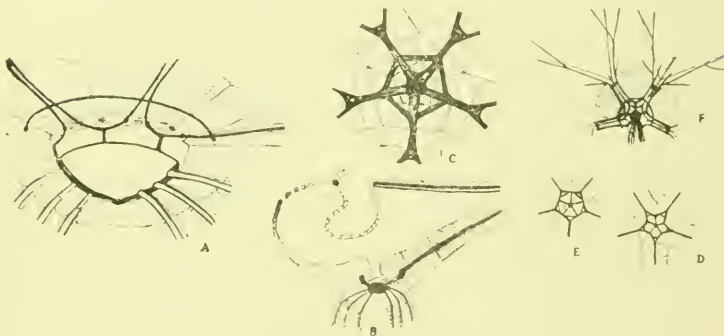


Fig. 33. NERVOUS SYSTEM OF CRINOIDS. A. Diagram of a section through the body of a crinoid showing nervous system by heavier lines. B. Diagram of a section of the nervous system of a crinoid, nerves in black, after Marshall. C, D, and E. Diagrams of the central nervous system of Crinoids, after Marshall and Carpenter. F. Diagram of the plan of the nervous system of a crinoid.

The commissural connectives between the aboral nerves co-ordinate movements and if these are cut the arms move independently.

The position of the radial cords within the bony plates comes about gradually from larval conditions when they are open, trough-like grooves. These grooves gradually close in.

The cirri each have nerves from the central aboral nerve mass. The arms, the cirri and the palps are tactile organs.

Hamann has shown nerve endings in the surface epithelium as well as by means of little projections with fine hairs at their ends.

Among the important contributions to the nervous system of this group are those of Carpenter, 1865-84, Teuscher, '76, Ludwig, '77, Hamann, '87, Cuenot, '91. The papers of Hamann, Carpenter, Marshall and Haanen are among the most valuable contributions to our knowledge of the nervous system.

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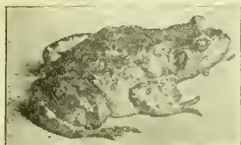
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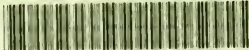
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